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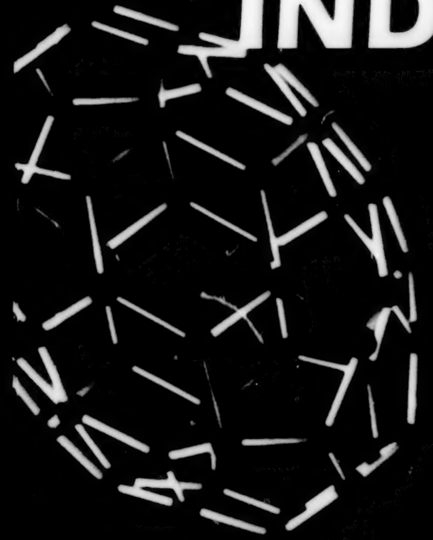

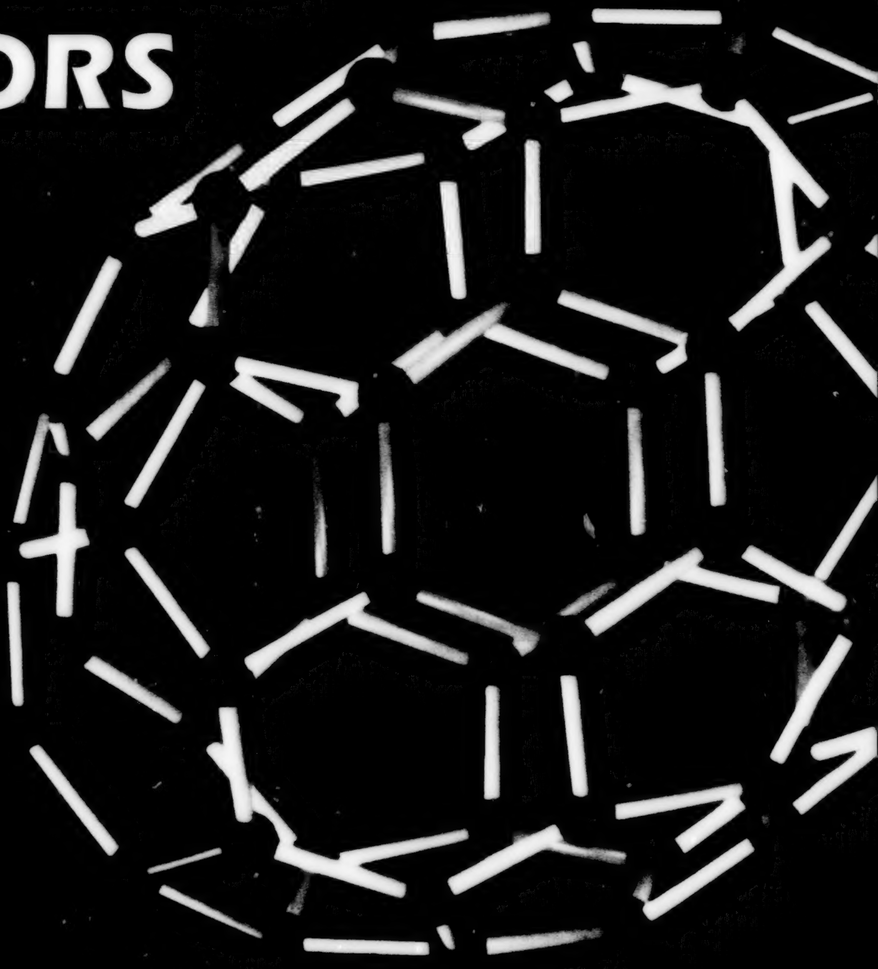

1991

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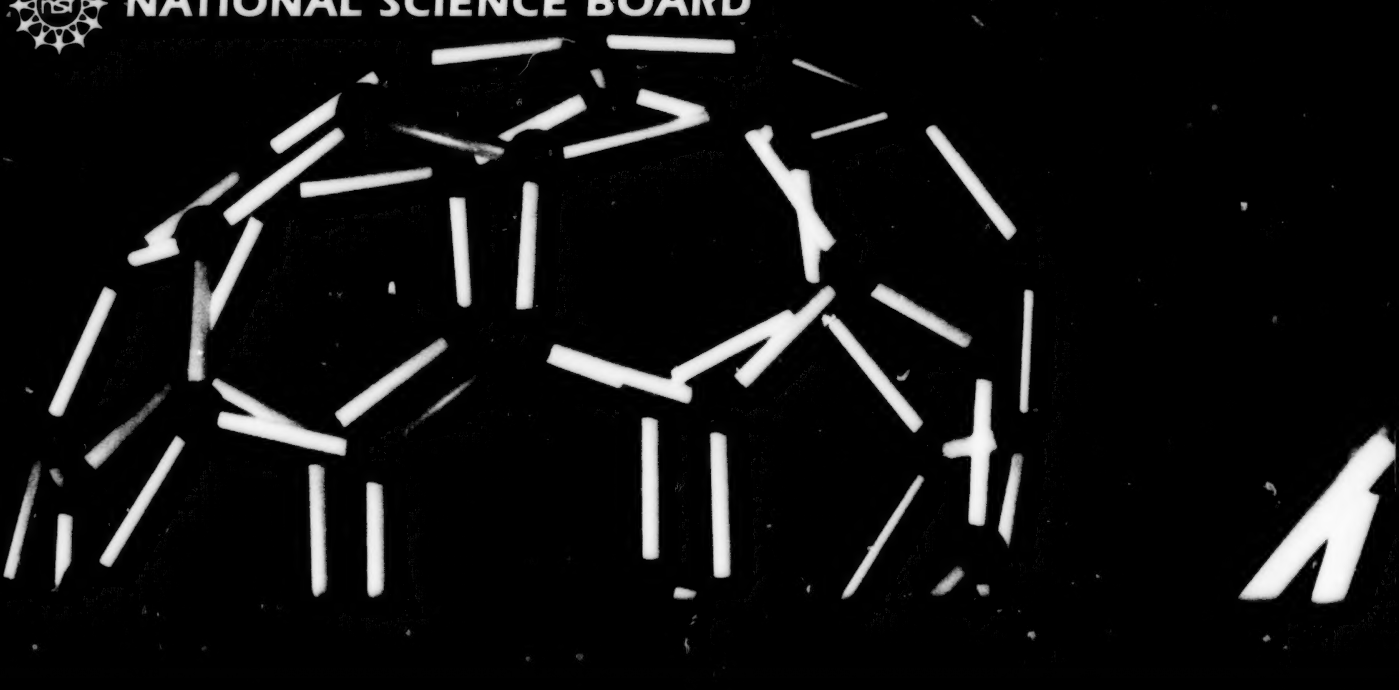

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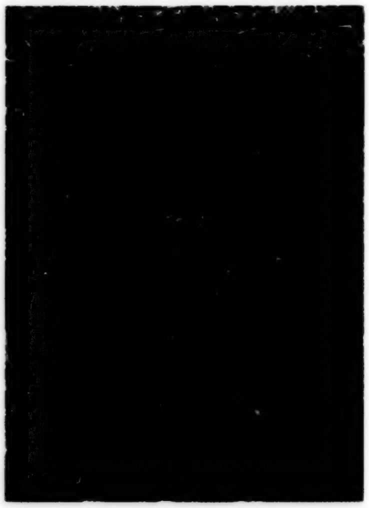

The Cover

Buckyballs—C_{60} buckminsterfullerene—as seen in selected snapshots from *quantum molecular dynamics* simulations of changes to the atomic structure of the molecule as it is heated from zero to 2000 degrees kelvin.

Buckyballs are new forms of carbon that open exciting new areas for experimental and theoretical investigations. The molecule holds promise for new superconducting materials and may someday be used to make new lubricants, batteries and high-strength polymers.

The computational method used to create the image reproduced above, called *quantum molecular dynamics*, takes advantage of the tremendous calculating power available only through state-of-the-art supercomputers. The soccerball-shaped image in the center of the above photograph shows the electron distribution of the molecule at one thousand degrees kelvin, with grey, green and orange denoting regions of successively greater electron density.

The ball and stick images spiraling outward from the central image show the changing atomic arrangements as the molecule is heated to 2000 degrees kelvin, with longer bonds appearing in yellow and the shorter ones in red. These calculations show that C_{60} is stable at very high temperatures, despite undergoing substantial shape-distorting soccerball-football oscillations.

The Image

The simulations were accomplished at the North Carolina Supercomputing Center. The *quantum molecular dynamics* code used to create the image runs at an average speed of over 200 MFLOPS on one Cray Y-MP processor. The graphics rendering of the picture was carried out on a Silicon Graphics 4D/280 GTX, using Wavefront and custom software. Work was done by T. Palmer, Cray Research, NC Supercomputing Center; J. Bernholc, Q.-M. Zhang, J.-Y. Yi, C. Brabec, NC State University. Further details are available in Q.-M. Zhang, J.-Y. Yi, and J. Bernholc, *Physical Review Letters* 66, 2633 (1991).

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Letter of Transmittal

December 1, 1991

My Dear Mr. President:

In accordance with Sec. 4(j)(1) of the National Science Foundation Act of 1950, as amended, it is my honor to transmit to you, and through you to the Congress, the tenth in the series of biennial Science Indicators reports—*Science & Engineering Indicators – 1991.*

These reports are designed to provide public and private policymakers with a broad base of quantitative information about U.S. science and engineering research and education and about U.S. technology in a global context.

U.S. Government and industry have led the world in recognizing the importance of science and technology for achieving national objectives. Their support for research and development (R&D), and especially basic research, is reflected in the data in these pages. But priorities and programs must be constantly redefined and reshaped to adapt to rapidly changing global economic, political, and social conditions. This report pulls together in a convenient format much of the data about science and technology pertinent to these decisionmaking processes.

The coverage is broad. U.S. and comparative foreign trends are tracked in precollege and college-level science, mathematics, and engineering education; scientists and engineers in the labor force; support and performance of research and development, with special detail on academic R&D; technological innovation and the international competitiveness of U.S. technology; and public attitudes toward, and knowledge about, science and technology.

Mr. President, the National Science Board is proud to call your attention to the fact that this tenth edition of the biennial Indicators marks 20 years since the Board initiated the report. It is widely used around the world for policymaking as well as serving as a model for national science policy data compilations. My National Science Board colleagues and I hope that your Administration and the Congress will continue to find this report useful as you seek solutions to our national problems.

Respectfully yours,

James J. Duderstadt
Chairman, National Science Board

The Honorable
The President of the United States
The White House
Washington, DC 20500

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Introduction

Twenty Years of Indicators

The publication of the 10th biennial volume in the *Science & Engineering Indicators* series signals the completion of 20 years of activity in the area. It is a time for celebration as well as a time for assessing the achievements and shortcomings of the activity. The anniversary also provides an opportunity for appraising the uses of the volumes in assisting the process of science and technology (S&T) policy formulation.

As the principal patron of *Indicators*, the U.S. Congress has already begun such an appraisal with the publication by its Office of Technology Assessment of *Federally Funded Research: Decisions for a Decade* (OTA-SET-490, Washington, DC: May 1991). The report contains a discussion of the *Indicators* volumes and adjudges them to be, "the most comprehensive look at the research system that is currently available" (p. 236). Critiques of the approaches taken in the *Indicators* volumes are noted and discussed. The authors further propose a variety of new indicators ranging from technology measures to fine detail indicators of the flow of research proposals and awards to Federal agencies.

Globalization of Indicators

The U.S. *Indicators* volumes, as they evolved during the 1970s, served as a model for the rapid growth of *Indicators*-type reports around the world during the 1980s. Governments have increasingly come to see science and technology policy as a key ingredient in their strategies for development and economic competitiveness. As a result, there is a strong movement toward the globalization of S&T indicators involving the development of truly comparable measures of S&T functions in different countries. The Organisation for Economic Cooperation and Development (OECD) has long been a forum for the creation of such comparative indicators, and now the European Community is moving decisively into the creation of data systems for assessment and evaluation of science and technology among its 12 member nations. Finally, the rapidly developing economic powers of the Asia and Pacific region are making efforts to construct comparable measures of their S&T activities. A working group of the newly formed Pacific Economic Cooperation Council (PECC) is dedicated to this activity.

What Is New in This Volume

Science & Engineering Indicators – 1991 continues to consolidate and work out the changes in structure introduced in the 1987 edition:

- In keeping with the policy pre-eminence of school science and mathematics education, the chapter on this topic has been expanded. Especially important are new national data on levels of performance of U.S. minority schoolchildren of different ages on science and mathematics performance tests.
- In the higher education chapter, there are new materials on time to degree as well as new international comparative data on S&E degrees.
- The overall picture of financial support of R&D is complemented by an exploration of changes in inter- and intra-sectoral cooperative R&D linkages. In addition, the section presents new information on state R&D expenditures.
- The formerly separate sections on industrial R&D and U.S. technology in a global context were combined for this volume. New analyses have been conducted on patent data as well as in the area of small high-technology business.
- In keeping with the theme of globalization of indicators, analyses of public attitudes toward, and public knowledge of, science and technology are presented with comparative data from 15 countries.

Acknowledgments

The National Science Board extends its appreciation to the staff of the National Science Foundation for preparing this report.

Organizational responsibility for the volume was assigned to the Directorate for Scientific, Technological, and International Affairs (STIA), Kurt G. Sandved, Acting Assistant Director. Gerard R. Glaser, Executive Officer, STIA, coordinated production and review of the document. The Directorate for Education and Human Resources (EHR), Luther S. Williams, Assistant Director, was assigned responsibility for the manuscript of one chapter.

Primary responsibility for the production of the volume within STIA was assigned to the Indicators Program, under the direction of Carlos Kruytbosch and Jennifer S. Bond of the Division of Science Resources Studies (SRS), Kenneth M. Brown, Director. Other units with major responsibilities for portions of the report were the Division of Policy Research and Analysis (PRA) in STIA, Peter W. House, Director, and the Office of Studies and Program Assessment (OSPA) in EHR, Kenneth J. Travers, Director.

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Overall editing of the report was performed by Nita Congress, consultant. Patricia Hughes and Pat Bryant of the NSF Printing Services Branch were responsible for the desktop publishing and printing process.

Overview of U.S. Science and Technology

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Overview of U.S. Science and Technology

SYNOPSIS

The extraordinary, and continuing, global political and economic changes of the past half decade are forcing fundamental reassessments of policy in many areas of public endeavor. Science and technology (S&T) policy is no exception. Patterns of resource allocation—for example, to civilian and military research, to basic and applied research and development, etc.—that made sense under earlier political and economic conditions now appear inappropriate. Because decisionmakers are still groping toward new policy formulations, the impact of these changes are, by and large, still too recent to be clearly reflected in S&T indicators. Nevertheless, some trends *are* apparent; these are outlined below.

Expenditures for Research and Development

In the United States the twin engines that powered the rapid growth of research and development (R&D) from the mid-1970s to the late 1980s have been decelerating—the economy has been in a recession, and the evaporation of the cold war has reduced the urgency for military R&D spending. The average annual increase in total U.S. R&D expenditures between 1985 and 1991 (in constant dollars) was 1.2 percent, compared with an annual growth rate of 6.9 percent from 1980 to 1985. The most recent estimates on change from 1989 to 1991 also show declining R&D expenditures.

Current estimates for *development* expenditures exhibit the sharpest downturn—a negative trend in constant dollars since 1988. The estimated trend in *applied research*, too, has been negative since 1989. The Federal Government is estimated to have reduced its R&D expenditures significantly from 1989 to 1991; estimates for U.S. industry R&D expenditures remained level during this period.

Only expenditures for *basic research* have continued to grow, albeit at a declining rate. The most recent estimate is for a 2.7-percent increase from 1990 to 1991. The statistics for expenditures for academic R&D also show continuing slow growth.

Internationally, total U.S. R&D expenditures continue to exceed those of its four closest industrial competitors combined, despite the fact that two of these countries (West Germany and Japan) outpace the United States in terms of R&D expenditures as a percentage of gross national product (GNP). However, as of 1989, these four countries together (the two named above plus the United Kingdom and France) spent 12 percent more than the United States on total nondefense-related R&D activities.

U.S. Technological Innovation

The United States has seen further slow erosion of its shares in global markets for high-technology goods. For example, in 1988 the United States supplied 37 percent of the world's high-tech products, slightly down from 40 percent in 1980. Although the country continues to maintain a trade surplus in high-tech goods, its 1988 balance was half the size its 1980 balance.

A more positive trend in the area of technological innovation is the upturn in patenting by U.S. inventors between 1983 and 1989.

Lastly in this area, an incipient trend worth watching is a possible tendency for U.S. corporations to spend an increasing portion of their corporate R&D funds at facilities abroad.

Academic R&D

Although academic R&D continued to grow during the late 1980s, it was at a slower rate than during the first half of the decade. Major investments were made during the decade in *research instrumentation* (with support coming primarily from Federal agencies) and the construction and refurbishment of *research facilities* (supported primarily by the institutions themselves). However, financial problems loom for research universities as the recession hits both state budgets and the various sources of income for private institutions, and as pressures mount for lower indirect cost reimbursement rates on Federal research grants and contracts.

Science and Engineering Personnel

The U.S. science and engineering (S&E) workforce extended its long growth trend through 1989 at an annual rate of approximately 4 percent. Expansion of S&E employment continued at a faster rate in nonmanufacturing jobs (primarily in the services sector) than in manufacturing jobs. The proportion of S&E jobs within the nonmanufacturing sector increased from 1.2 percent in 1980 to 1.7 percent in 1989; this rise translated into a nearly 50-percent increase in S&E job opportunities in this sector during the decade. The increase in the S&E share of manufacturing jobs was also sizable—from 3.7 percent in 1980 to 5.1 percent in 1989—despite a decrease in total manufacturing jobs.

Adequacy of the supply of new scientists and engineers during the 1990s continued to prompt concern, especially in light of relatively unfavorable demographic factors. Indicators of supply and demand examined here suggest relative stability in S&E labor markets during the 1990s: lower demographic growth will be matched by generally slower economic growth. Within this framework, however, it can be expected that rapid technological change will almost certainly generate spot shortages and surpluses in specific areas.

Precollege Science and Mathematics Education

Concerns also continued to be raised about the quality (and quantity) of U.S. science and mathematics education and the attractiveness of S&E careers to U.S. citizens. In international comparative achievement tests in science and mathematics, U.S. boys and girls score lower than their peers in many other countries. An exploratory study suggests that U.S. grade schoolers receive significantly less exposure to mathematics and science instruction in early years than do their peers in Japan and Taiwan.

Higher Education for Scientists and Engineers

Undergraduate S&E degrees continue their long, gradual decline as a share of all degrees. Data on the plans of freshmen entering college in 1989 and 1990 suggest, however, that degrees in the natural sciences, engineering, and computer sciences may be bottoming out and might begin to increase in the early 1990s.

Meanwhile, the proportions of *foreign citizens* enrolled in U.S. natural science, mathematics, computer science, and engineering graduate programs and receiving S&E doctoral degrees continue to increase apace. In 1990 foreign citizens accounted for about one in four graduate students in these fields and for one in three doctoral degree awards in these fields.

Public Perceptions of Science and Technology

As measured in the National Science Foundation's biennial survey of U.S. public perceptions of science and technology matters, U.S. adults remain strongly supportive of the scientific enterprise in general and of Federal support for basic research in particular—"even if it brings no immediate benefits." The public did, however, express increased concern about the use of animals in research.

U.S. adults exhibited mounting concern about the quality of science and mathematics education in U.S. schools. There was a significant increase between 1985 (60 percent) and 1990 (71 percent) in the proportions who felt that too little was being spent on education in the United States.

Comparative data from the United States, Canada, and the 12 countries of the European Community on public knowledge about S&T show strikingly similar degrees of knowledge. These new comparative data also indicate that Americans and Canadians view science and technology more positively than do Western Europeans.

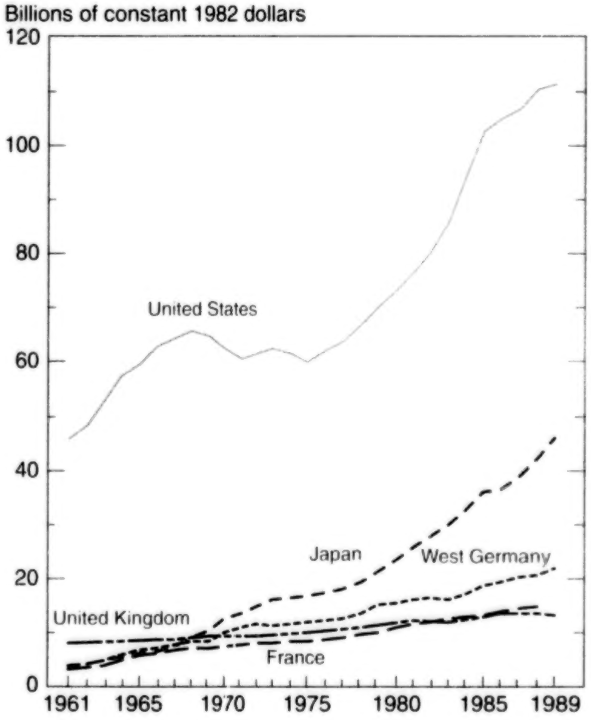
U.S. R&D Expenditures in a Global Context

Total research and development (R&D) expenditures of the United States continue to exceed those of its four closest industrial competitors. (See figure O-1.) However, two of these countries, West Germany and Japan, continue to outpace the United States in terms of R&D expenditures as a percentage of gross national product (GNP). (See figure O-2.) Some other small industrial nations such as Sweden also outstrip the United States on this measure of relative national resources devoted to R&D.

In terms of economic competitiveness, a longstanding trend continued: the United States spent a significantly lower proportion of its GNP on nondefense R&D activities than did Japan and West Germany. (See figure O-2.) In 1989, Japan, West Germany, the United Kingdom, and France together spent 12 percent *more* than the United States on nondefense-related R&D activities. The bulk of this increase is attributable to rapid growth in Japanese nondefense R&D. (See figure O-3.)

R&D spending growth in the United States continued to slow. The average annual increase in total U.S. R&D expenditures between 1985 and 1991 was estimated at 1.2 percent in constant dollars. The annual growth rate from 1980 to 1985 was 6.9 percent. The sharpest downturn appears in the estimates for development expenditures—a negative trend, in constant dollars, between

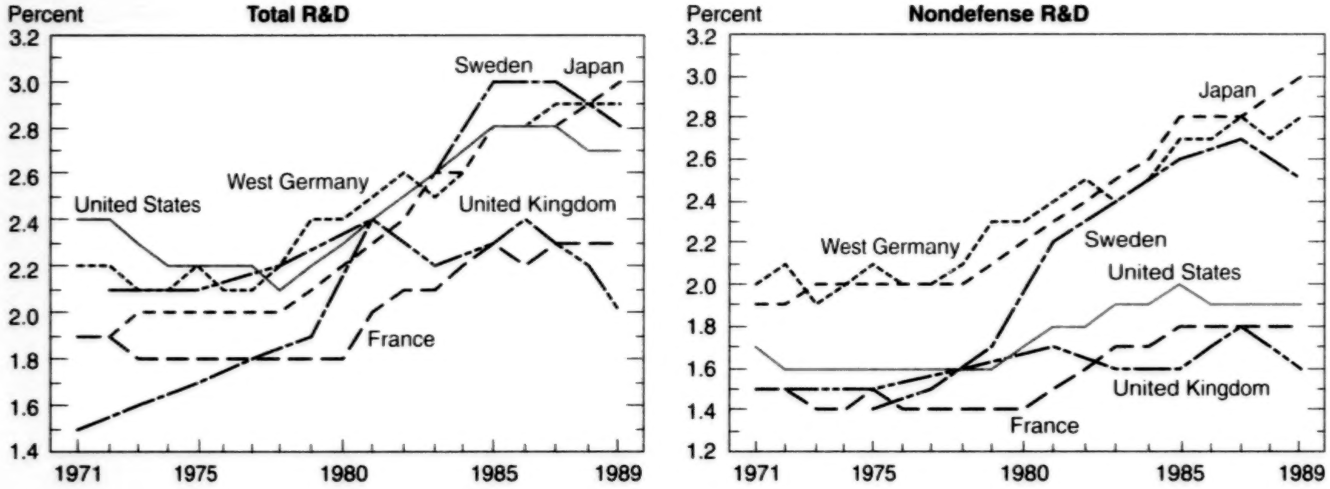
Figure O-1.
R&D expenditures, by country



See p. 107 and appendix table 4-26.

Science & Engineering Indicators – 1991

Figure O-2.
R&D as a percentage of GNP, by country



NOTE: Some data are estimates.
See p. 108 and appendix tables 4-26 and 4-27.

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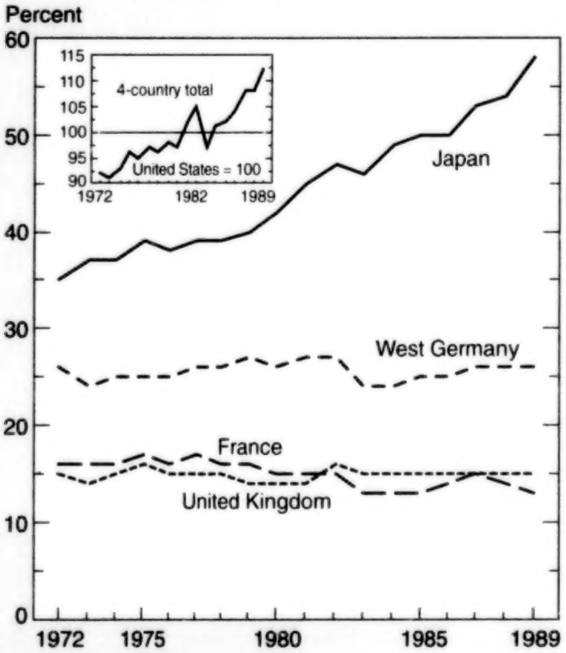
1988 and 1991. (See figure O-4.) A similar but less accentuated trend occurred in applied research expenditures. Only expenditures for basic research have continued to grow. This growth, though, has been at a declining rate: a 2.7-percent increase in basic research spending is estimated for 1990 to 1991. Because most academic R&D is basic research, the data also show a continuing slow growth of expenditures for academic R&D.

The decline in R&D growth stems from policy shifts in the two major sources of R&D funding—the Federal Government and U.S. corporations. Reduced Federal

Figure O-3.
Nondefense R&D: foreign spending as a percentage of U.S. spending



NOTE: Some data are estimates.
See p. 109 and appendix table 4-27.

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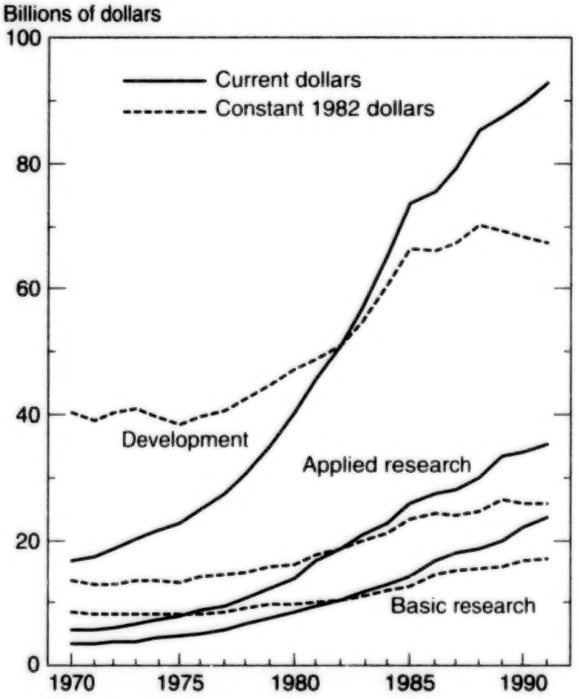
Figure O-4.
U.S. R&D expenditures, by character of work



NOTE: Data are preliminary for 1990 and estimated for 1991.
See p. 91 and appendix tables 4-4, 4-5, and 4-6.

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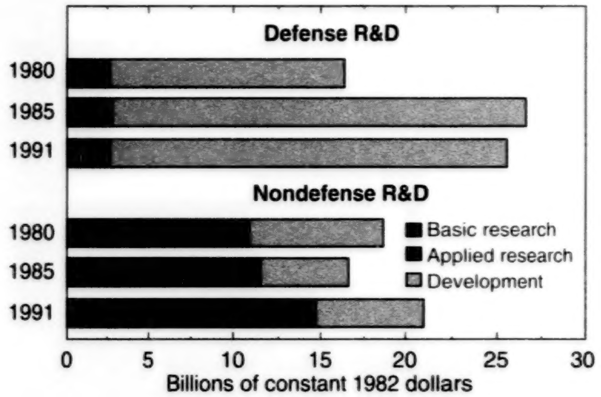
Figure O-5.
Relative changes in Federal obligations for defense and nondefense R&D, by character of work



NOTE: Defense R&D equals the Department of Defense obligations for the designated year. Nondefense obligations include some defense-related obligations from the Department of Energy.

See p. 94 and appendix table 4-8.

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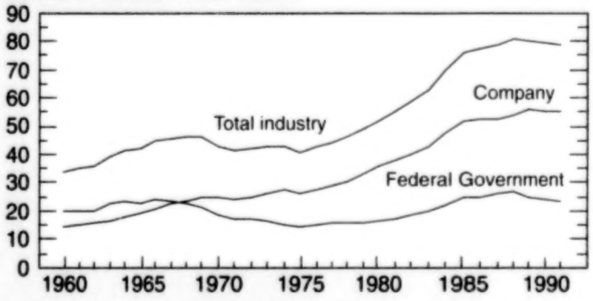
priorities for military R&D between 1985 and 1991 resulted in shrinking support for defense-related development work and increases in nondefense basic research. (See figure O-5.) Company-funded R&D, responding to the general economic slowdown, is estimated to have leveled off between 1989 and 1991. (See figure O-6.)

Scientists and Engineers in the Workforce

The United States continued to lead the world of industrial market economies in nonacademic scientists and engineers per 10,000 people employed in the labor force. (See figure O-7.) The United States also led in the proportion of its science and engineering (S&E) labor force that is female.

Figure O-6.
Expenditures for industrial R&D, by source of funds



NOTE: Data are preliminary for 1990 and estimated for 1991.

See p. 91 and appendix table 4-2.

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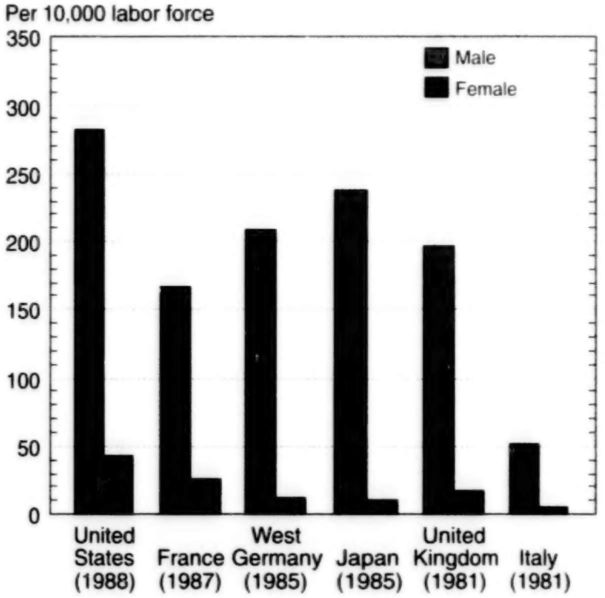
Figure O-7.
Nonacademic scientists and engineers per 10,000 labor force, by country and gender



See p. 84 and appendix table 3-17.

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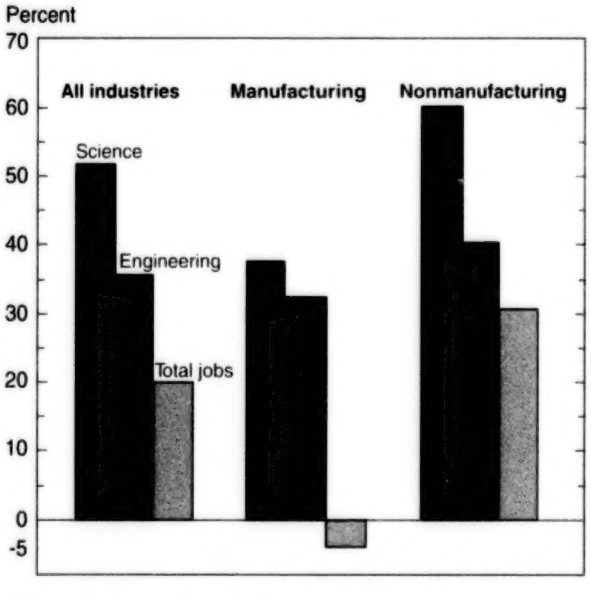
The U.S. S&E workforce in private industry continued a long growth trend through 1989 at an annual rate of almost 4 percent. Expansion of industrial S&E employment continued at a faster rate in nonmanufacturing (primarily service) jobs than in manufacturing jobs. (See figure O-8.)

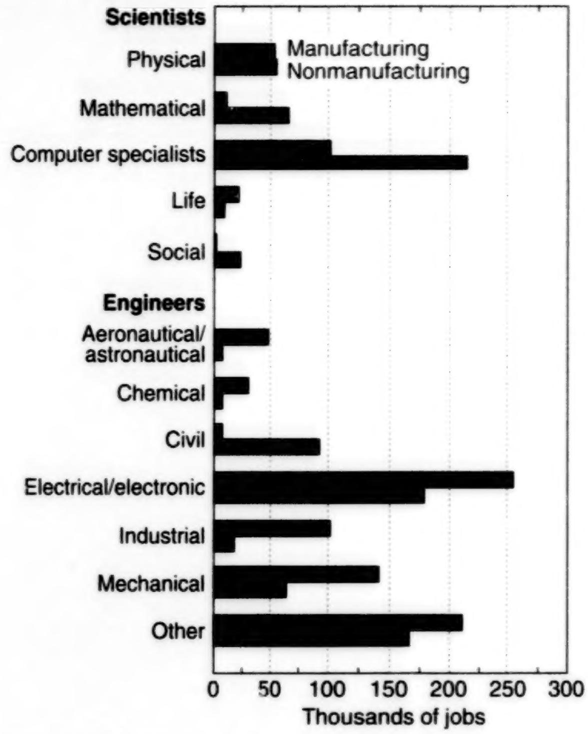
Figure O-8.
Growth in science, engineering, and total jobs in private industry, by sector: 1980-89



See p. 67 and appendix table 3-1.

Science & Engineering Indicators – 1991

Figure O-9.
Private industry jobs in science and engineering, by occupation and sector: 1989



See p. 70 and appendix table 3-1.

Science & Engineering Indicators – 1991

The proportion of S&E jobs within the nonmanufacturing sector increased from 1.2 percent in 1980 to 1.7 percent in 1989, resulting in a nearly 50-percent increase in S&E job opportunities in this sector during the decade.

The increase in the S&E share of manufacturing jobs was also sizable—from 3.7 percent in 1980 to 5.1 percent in 1989, despite the overall decrease in total manufacturing jobs during the period. (See figure O-8.)

Employment patterns within U.S. private industry reveal strong twin tendencies (1) for scientists (except life scientists) to be employed in nonmanufacturing companies, and (2) for engineers (except civil engineers) to be employed in manufacturing enterprises. (See figure O-9.)

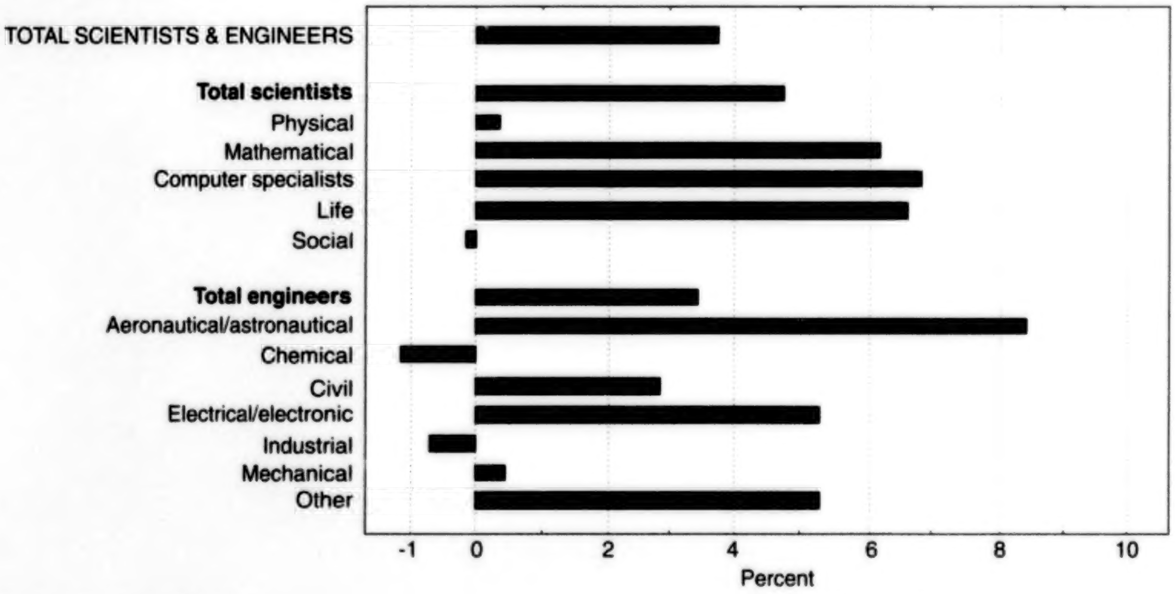
Scientific occupations—such as mathematical and life scientists and computer specialists—and engineering occupations—such as aeronautical/astronautical and electrical/electronic—grew at a faster rate than the average for all occupations. (See figure O-10.) Employment in physical science occupations grew less than 0.5 percent annually, while there was negative growth in social science and chemical and industrial engineering jobs.

A significant shift in the employment of U.S. doctoral scientists and engineers from 1977 to 1989 caused an increasing proportion of them to be employed in industry and a decreasing proportion to be employed in colleges and universities. (See figure O-11.)

Precollege Education in Math and Science

The performance of U.S. schoolchildren on mathematics and science tests has been tracked for over 20

Figure O-10.
Rate of job growth in private industry, by occupational specialty: 1980-89



See p. 70 and appendix table 3-1.

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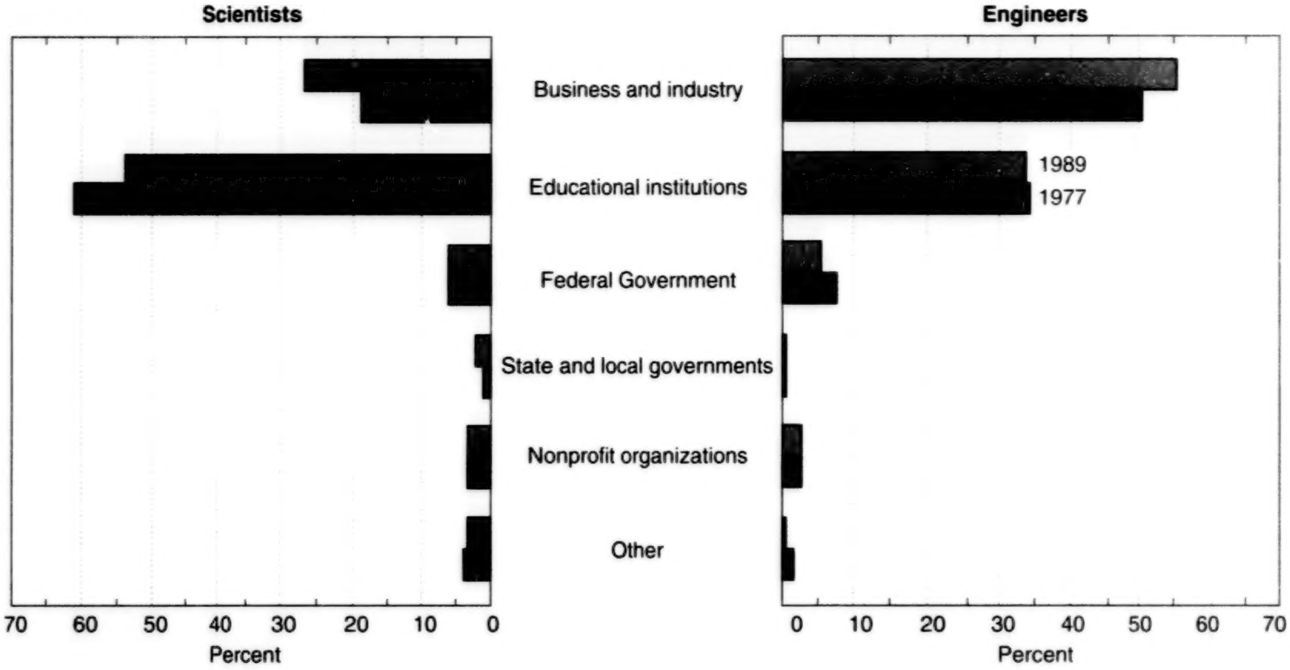
Figure O-11.
Employed doctoral scientists and engineers, by sector of employment



See p. 77 and appendix table 3-15.

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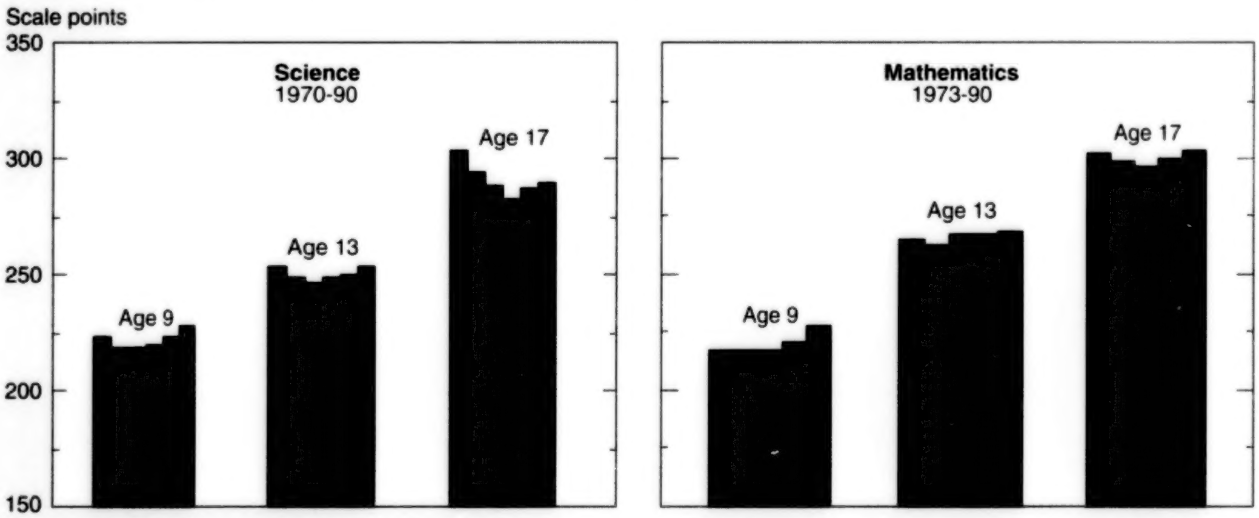
years in the National Assessments of Educational Progress. The overall pattern in the two decades showed a decline in test scores during the 1970s, followed by recovery to the 1969 level by 1990. This pattern holds true for 9- and 13-year-old students in both mathematics and science. By 1990, 17-year-old students had regained their performance levels of 1973 in mathematics, but in science they remained below their achievement level in 1969. (See figure O-12.)

Minorities showed greater gains in test scores than did whites during the two decades. In science, black and Hispanic 9- and 13-year-old students showed gains

Figure O-12.
Trends in average science and mathematics proficiency in the United States



NOTE: Test years for science were 1970, 1973, 1977, 1982, 1986, and 1990. Test years for mathematics were 1973, 1978, 1982, 1986, and 1990.

See pp. 17-20 and appendix tables 1-1 and 1-4.

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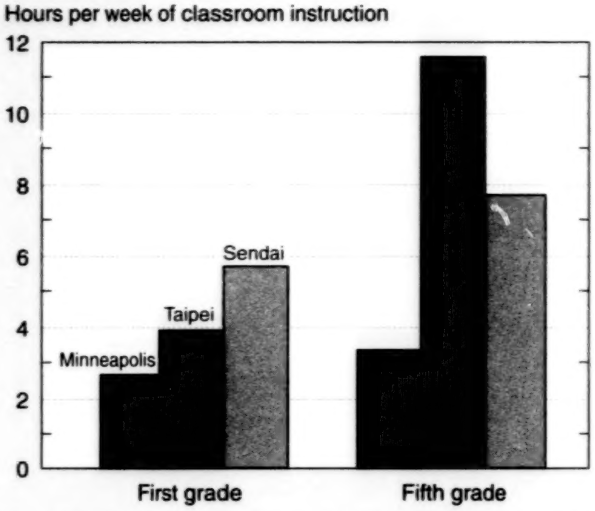
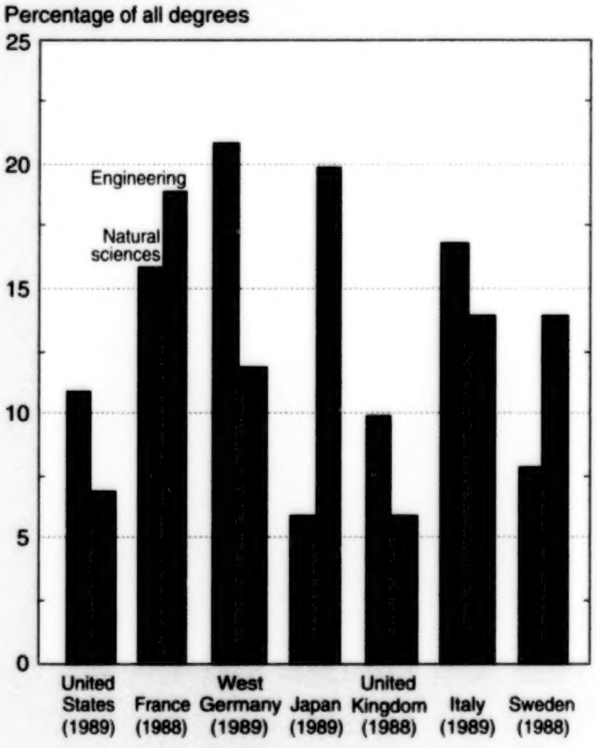
between 1970 and 1990, while 17-year-old minority students regained their earlier levels of achievement. In mathematics, Hispanic 9- and 13-year-olds made significant gains from 1978 to 1990, while all three age groups among blacks made gains during the period.

Figure O-13.
Time spent on mathematics instruction



See pp. 21-22. *Science & Engineering Indicators – 1991*

Figure O-14.
First university degrees, by field for selected countries



See p. 85 and appendix table 3-23.

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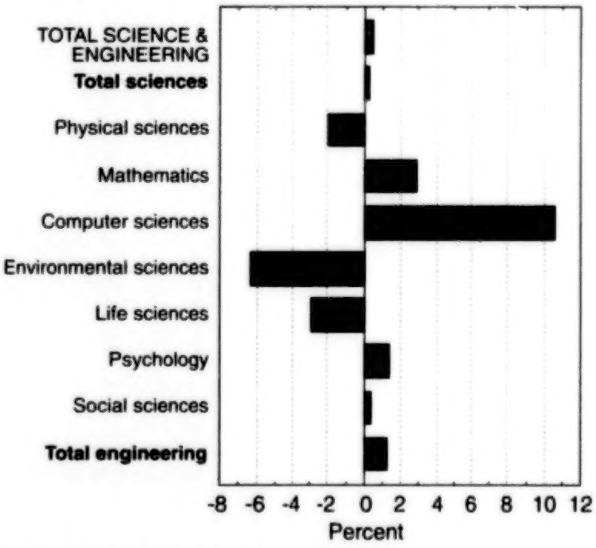
A new international comparative study of factors contributing to science and mathematics test performance sheds some light on findings reported in previous editions of *Science & Engineering Indicators* concerning the relatively poor performance of U.S. children on these international tests. Comparisons of first and fifth grade classroom time dedicated to mathematics in schools in Minneapolis, Sendai (Japan), and Taipei (Taiwan) showed that, on average, children in the two Asian cities spent over twice the amount of time on mathematics in the classroom as did Minneapolis children. (See figure O-13.) Other cultural and economic factors may also be affecting behavior, but degree of exposure to subject matter is an important variable.

Higher Education in S&E

A seeming pervasive anomaly in the United States is the fact that it has the highest percentage of scientists and engineers in its labor force (see figure O-7), as well as practically the lowest (less than 20 percent) proportion among market economy countries of first university degrees in S&E fields. (See figure O-14.) The root of the situation lies in the magnitude of the U.S. higher education enterprise and the high proportion of young adults who participate in it.

There has been continuing concern over the long-term gradual decline in the choice of certain science majors by U.S. college students. (See figure O-15.) The growth in majors in the computer sciences and mathematics during the 1980-89 decade overshadows the decline in majors in the core physical and life sciences. However, data on the plans of freshmen entering college in 1989 and 1990 suggest that the level of degrees in the natural

Figure O-15.
Annual change in science and engineering baccalaureates, by field: 1980-89



See p. 51 and appendix table 2-7.

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sciences, engineering, and computer sciences may be bottoming out and might begin to increase in the early 1990s. (See figure O-16.)

The decline in choice of S&E majors by U.S. undergraduate students has been accompanied by a rapid increase in the representation of non-U.S. citizens in S&E graduate enrollments and among S&E doctorate degree recipients. In 1989, about one-quarter of all S&E students enrolled in U.S. graduate S&E departments were non-U.S. citizens. Foreigners constituted about one-third of the graduate students enrolled in the physical sciences, mathematics, and engineering. (See figure O-17.) Among 1990 S&E doctorate recipients from U.S. universities, the foreign presence was even more marked—over one-third were non-U.S. citizens. In engineering, mathematics, and the computer sciences, the majority of Ph.D. degree recipients (over 55 percent) were non-U.S. citizens.

Figure O-16.
Freshman choice of probable major

Probable major	1982	1984	1986	1988	1990
	Percent				
Biological sciences . . .	3.7	4.2	3.9	3.7	3.7
Engineering	12.6	11.0	10.9	9.5	9.6
Physical sciences[1]. . . .	2.5	2.6	2.4	2.1	2.4
Social sciences.	5.8	6.7	8.0	9.5	9.6
Computer sciences . . .	4.4	3.4	1.9	1.7	1.7
Business	24.2	26.4	26.9	25.6	21.1
Education.	6.0	6.5	8.1	9.3	9.9
Arts and humanities. . .	8.2	7.7	9.0	9.3	8.9
One of the professions	13.3	14.1	11.7	12.2	15.2

[1] Includes mathematics.

SOURCE: Cooperative Institutional Research Program, University of California at Los Angeles, *The American Freshman: National Norms* (Los Angeles: Graduate School of Education, UCLA, ongoing annual series).

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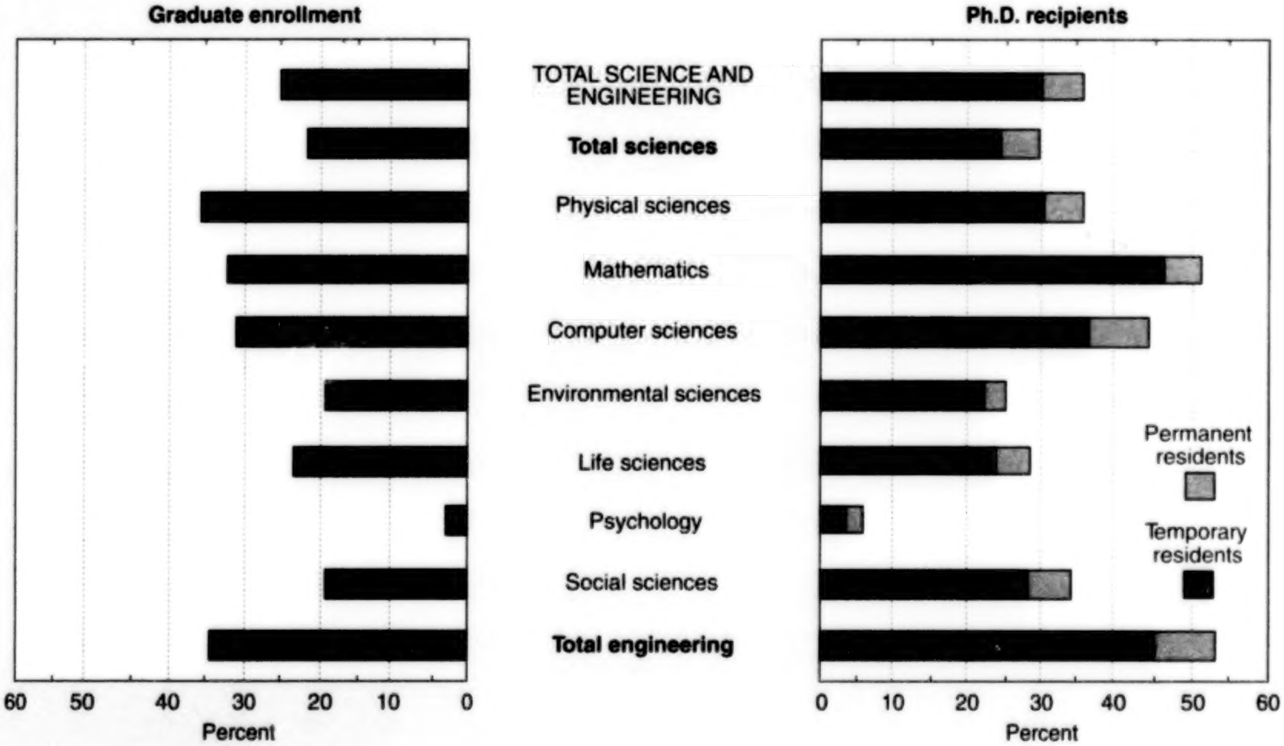
Research Outputs and Academic Research

The percentage distribution of world scientific publications by country shows that U.S.-based authors produce slightly over one-third of all publications. (See figure O-18.) This proportion has changed little over the last two decades. Japan and Canada have made small and possibly significant increases in their shares of world literature. A new tabulation shows the world share of the European Community countries to be slightly more than one-quarter.

The bulk of world scientific publications are written in universities, and U.S. universities have been able to maintain a modicum of growth in their research expenditures in recent years despite the overall slowdown in

Figure O-17.
Foreign citizen representation in 1990 U.S. science and engineering graduate education



See p. 58 and appendix tables 2-23 and 2-24.

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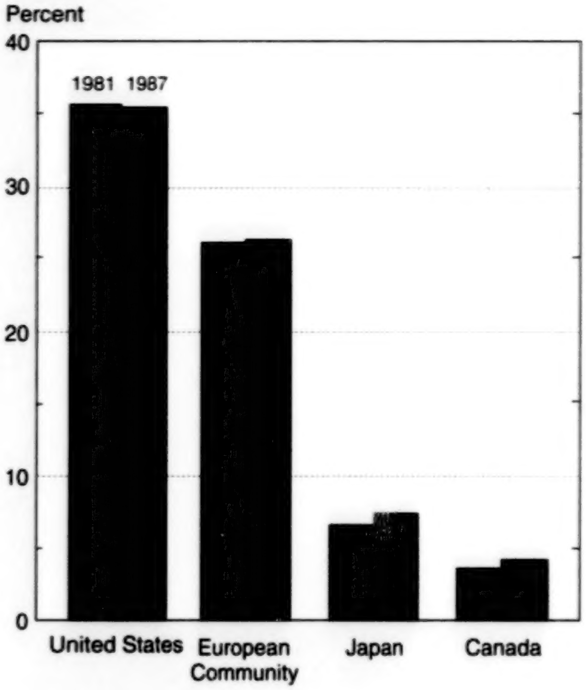
Figure O-18.
Contributions of selected countries/regions to world literature



See p. 130 and appendix table 5-27.

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research funding. From 1985 to 1991, the annual rate of increase of academic R&D expenditures was 6.3 percent, but between 1990 and 1991 this rate shrank to 2.9 percent. (See appendix table 4-3.)

The past decade has seen a significant decline in the share of Federal funds for academic R&D—from roughly 65 percent in 1980 to close to 55 percent in 1991. (See figure O-19.) There have been corresponding percentage increases from several non-Federal sources including academic institutions themselves, industry, and state and local governments.

Non-Federal sources have also provided the lion's share of the decade-long increase in academic investments in R&D facilities construction and refurbishment. (See figure O-20.)

Technological Innovation and Global Markets

Patenting is admittedly an imperfect indicator of technological innovation, yet it does provide a sense of the trends in innovative activities. From about 1978 to 1988, foreign-owned patents gradually increased their share of total U.S. patents—accounting for nearly half of all patents granted in 1988. Between 1988 and 1989, however, patents granted to U.S. inventors increased faster than did foreign-owned patent grants. (See figure O-21.) Japanese-owned patents continued to grow faster than those owned by any other industrial nation; Japanese inventors received just over 20 percent of all new U.S. patent awards in 1989.

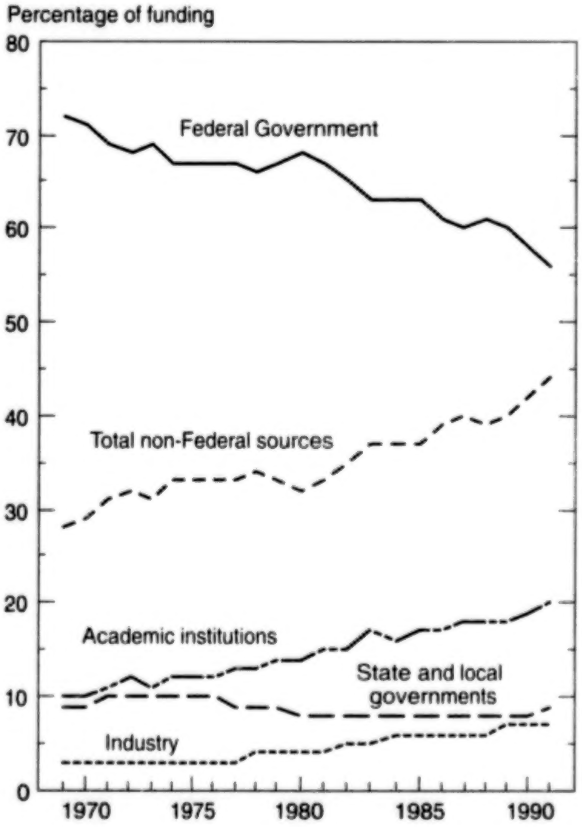
The strength of Japanese high-technology industry is also reflected in data on country shares of global markets for high-tech goods. Between 1980 and 1988, Japan increased its share of the global high-tech market from about 18 percent to nearly 27 percent. The United States and the European Community each lost about 4 percentage points of their respective global market shares in the same period. (See figure O-22.)

Trade balances in high-technology goods provide another indicator of economic strength in various areas. The overall pattern of trade balances between 1980 and 1988 mirrors the findings on country shares—the Japanese have tripled their positive trade balances, while the United States and the principal European countries have greatly reduced their positive balances. France, in fact, showed a negative balance for 1988. (See figure O-23.)

Public Attitudes on Science and Technology

The U.S. public continues to give overwhelming approval to Federal support for basic research, "even if it

Figure O-19.
Sources of academic R&D funding, by sector



NOTE: Data for 1990 and 1991 are estimates.

See p. 117 and appendix table 5-2.

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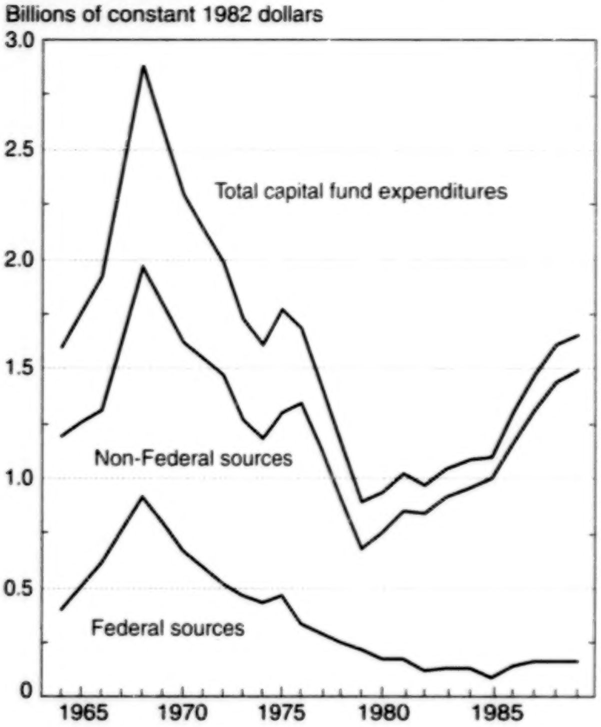
Figure O-20.
Federal and non-Federal capital fund expenditures for academic science and engineering



See p. 122 and appendix table 5-10.
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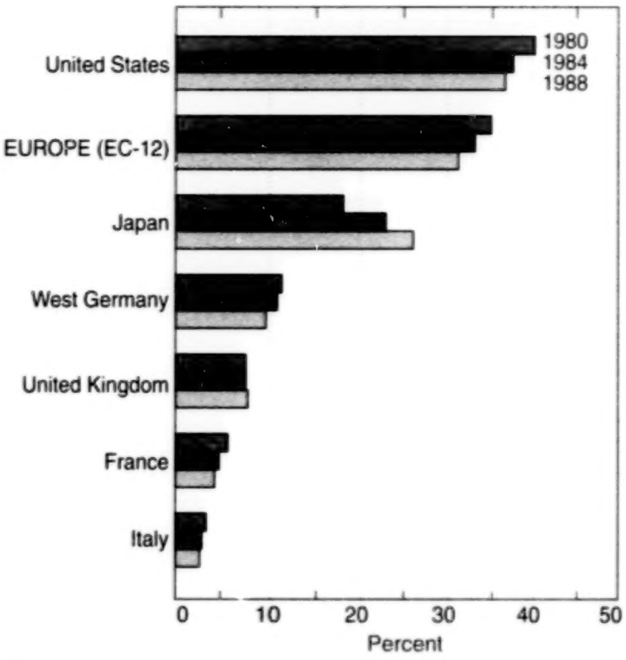
Figure O-22.
Share of global high-tech markets, by country



See p. 137 and appendix table 6-3.
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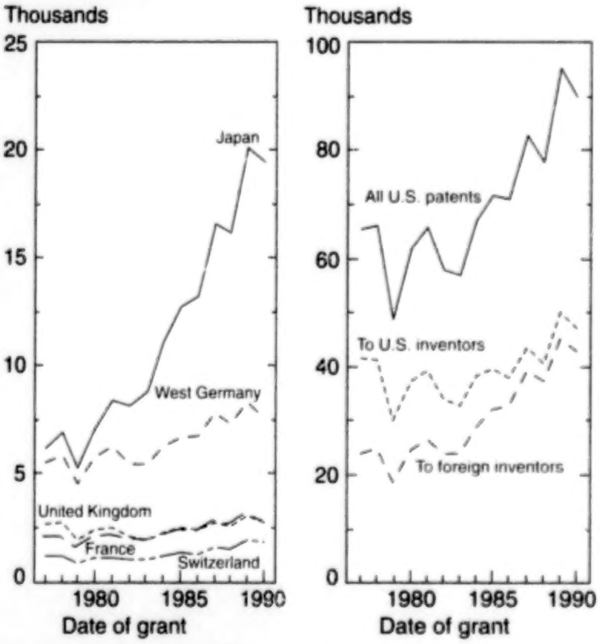
Figure O-21.
U.S. patents granted to foreign inventors, by nationality of inventor



See pp. 147-49 and appendix table 6-21.
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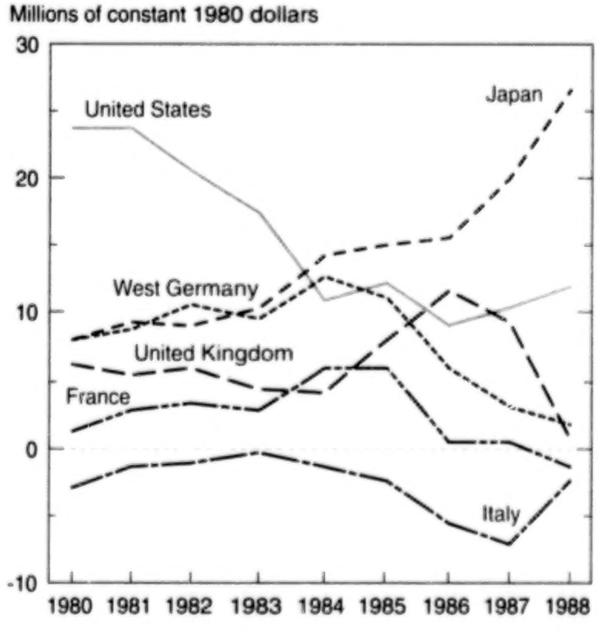
Figure O-23.
Trade balances for high-tech industries in selected countries



See p. 140 and appendix table 6-8.
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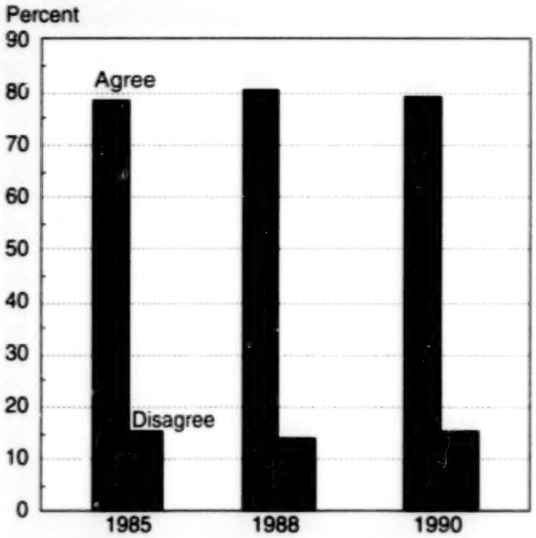
three national U.S. surveys in 1985, 1988, and 1990 are remarkably stable. (See figure O-24.)

The U.S. public does, however, express an increasing concern with the quality of U.S. science and mathematics education in the schools. (See figure O-25.) The public increasingly believes the quality to be inadequate and feels that high school students should be required to take a science course every year. In a five-survey sequence from 1981 to 1990, there was a more than 15-percentage point increase in the proportion of the public that says the Government is spending too little on improving education.

The rapidly growing field of international comparative surveys of public attitudes toward, and knowledge about, science and technology is beginning to yield important findings. For example, the average level of scientific knowledge, as measured by a battery of 10 factual questions about science, was almost exactly the same in the 12 countries of the European Community as in a national U.S. survey. (See figure O-26.) However, the United States ranked below most of the advanced industrial European nations, generally outstripping the lesser developed countries of Europe.

Figure O-24.
Federal funding of basic research

"Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Federal Government."



See p. 177 and appendix table 7-7.
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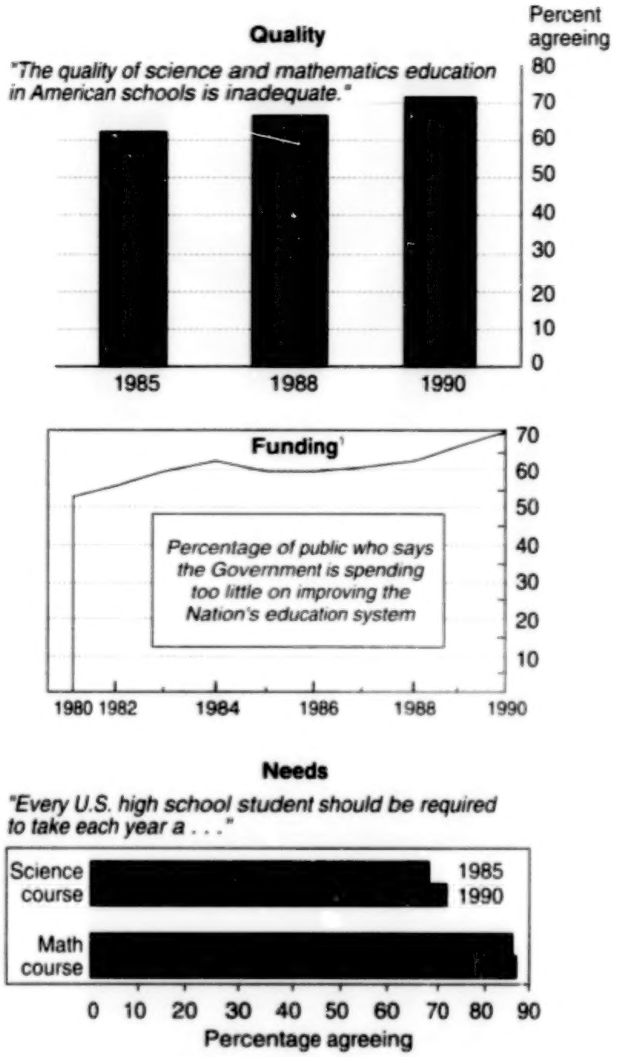
Figure O-25.
Public attitudes toward education



[1] Survey was not conducted in 1981.

See pp. 179-80 and appendix tables 7-7 and 7-14.
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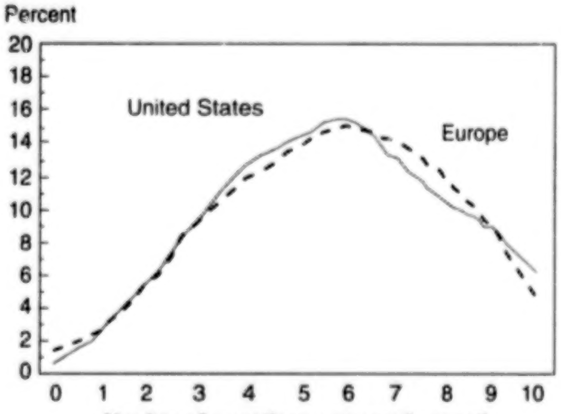
Figure O-26.
Scientific knowledge in Europe and the United States



See pp. 187-88 and appendix table 7-20.
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Chapter 1
Precollege Science and Mathematics Education

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Precollege Science and Mathematics Education

HIGHLIGHTS

Student Achievement

- **In both science and mathematics, test scores on national assessments showed improvements throughout the 1980s.** Achievement trends for 9-, 13-, and 17-year-old students showed a pattern of declining proficiency in the 1970s, followed by recovery in the 1980s. *See pp. 17-20.*

- **In science, the improvements 17-year-olds made in the 1980s did not offset the declines during the 1970s.** In 1990, average student proficiency among 17-year-olds remained below that in 1969. Among 9- and 13-year-olds, recent gains returned performance to levels students attained two decades ago. *See pp. 17-18.*

- **In mathematics, at ages 9 and 13, average student proficiency was somewhat higher in 1990 than in 1973.** Performance by 17-year-olds returned to its earlier level. *See p. 18.*

- **White students had consistently higher average achievements than their black and Hispanic counterparts in both science and mathematics.** However, both minority groups made considerable improvements compared to whites. *See pp. 17-18.*

- **The gains in student proficiency that occurred in science and mathematics during the 1980s appeared to be in lower level skills and basic concepts.** Nearly all students were learning basic facts and skills, but few showed a capacity for complex reasoning and problem-solving. *See pp. 17-20.*

- **North Dakota, Montana, Iowa, Nebraska, and Wisconsin were the only states where one-fifth or more of eighth grade students demonstrated a grasp of mathematics problems involving fractions, decimals, percents, and simple algebra.** These states were among the highest scoring states to participate in a 1990 state-level assessment. *See p. 20.*

- **U.S. high school seniors showed an overall weak grasp of geography.** Males outperformed females by a larger margin in geography than in any other subject tested. *See p. 20.*

- **In an assessment of mathematics achievement by students in one American and two Asian cities, the Americans were at a relative disadvantage in mathematics as early as grade 1.** This finding indicates that factors at home as well as at school must be responsible for these differences in achievement. *See pp. 21-22.*

Student Interest in Science and Mathematics

- **Nearly 30 percent of all grade 7 students expressed a preference for a career in science or engineering, but the percentage of students expressing this interest declined steadily throughout the middle and high school years.** By grade 12, fewer than 1 in 4 male students and only 1 in 10 female students expressed similar interests. *See p. 24.*

- **Of high school seniors scoring above the 90th percentile on the quantitative Scholastic Aptitude Test in 1990, about 45 percent expressed an interest in majoring in science and engineering in college.** This finding shows that science and mathematics continue to be of considerable interest among top high school students. *See p. 23.*

Student Coursework

- **Four times as much time was spent on reading instruction as was spent on science instruction in elementary school.** Only half of all third graders received science instruction on a regular basis. Twice as much time was spent on elementary mathematics lessons as on science. *See p. 27.*

- **Largely as a result of states raising their graduation requirements, the number of credits earned in science by high school graduates increased during 1982-87.** Recent data show that enrollment in biology continued to increase, while enrollment in chemistry and physics leveled off. *See p. 25.*

- **Mathematics coursetaking continued to increase from 1987 to 1990 in algebra, algebra 2, and calculus.** However, fewer than half of all high school graduates took algebra 2. *See pp. 25-26.*

Teachers and Teaching

- **In middle schools, science teachers felt less qualified to teach their subjects than their colleagues teaching mathematics.** Fewer than half of all middle school biology teachers and about one-fifth of physical science teachers felt they were teaching the subject for which they were best qualified. Two-thirds of mathematics teachers felt they were teaching their best qualified subject. *See p. 31.*

- **About 40 percent of middle school biology teachers majored or minored in that subject in college,** compared with about 30 percent of middle school teachers of physical science and mathematics. *See p. 31.*

- **Less than half of all high school physical science teachers felt they were assigned to classes in the subject they were best qualified to teach**, compared with about three-quarters of biology and mathematics teachers. *See p. 32.*

The Policy Context

- **Educational reforms increasing high school graduation requirements have exerted a powerful influence on schooling.** A study of six states found that reforms have led to different course offerings in science and mathematics, new coursetaking patterns, more attention to the knowledge and skills addressed by high school exit examinations, and adjustments in teacher assignments. *See p. 39.*
- **Implementation of state and local policies to increase the teaching of higher order thinking and analytical skills has been inhibited by lack of school resources** for staff development and for science laboratory facilities and equipment. *See p. 39.*

Introduction

Chapter Focus

Traditionally, American education has pursued several goals: developing intelligent and knowledgeable citizens, creating a skilled workforce, and ensuring fairness in access to education. Today, our educational system faces special challenges in achieving each of these goals. Citizens now need a basic understanding of science, for example, to make well-informed decisions about a variety of public policy areas—questions about health and related fields, such as those raised by research into our genetic inheritance; concerns about global warming and other environmental issues; and choices about explorations ranging from the atom to near-earth and outer space.

In the past, a relatively small number of highly skilled scientists and engineers flowing through the education and career "pipeline" were enough to maintain U.S. preeminence in science and technology. Today, the economy requires that rank and file workers in many industries possess the skills and abilities necessary to operate complex equipment and machinery and solve production problems as they arise. Today's production workers no longer simply wield tools; they also monitor quality, look for problems, repair complex equipment, and plan work loads and procedures. Office workers manipulate high-technology machines and handle large amounts of information (MSEB 1989, p. 3).

The requirements of today's economy make the need for fair access to education particularly acute. Both the entry-level workforce and the school population are composed of increasing proportions of women and minorities, groups that traditionally have not participated at a high rate in science and mathematics education and occupations.

White women comprise only 10 percent of all employed scientists and engineers, although they account for 43 percent of the U.S. population (Task Force 1989). Women appear to leave the pipeline by choice. As girls progress through the precollege science and mathematics curriculum, they differ little from boys in participation or achievement until the upper grades, when many of them decide to drop out of the higher level courses such as physics and calculus. Studies of gender differences suggest that most of these decisions are due to the accumulated effects of gender role experiences at home, in school, and in society (NRC 1989).

Blacks comprise 12 percent of the population and Hispanics 9 percent, but each group represents only 2 percent of all employed scientists and engineers. By the year 2000, one in every three American students will be a minority; by 2020, if current trends continue, today's minorities will become the majority of students in the United States. Many of these minorities turn away from science and mathematics courses early in life, partly because most go to large city schools and schools in impoverished areas where they receive an inadequate basic education, including poor instruction in science and mathematics (NRC 1989).

The schooling experiences of minorities play a substantial role in their decision to leave the pipeline. At the elementary level, the large majority of schools serving disadvantaged students treat only two subjects rigorously—reading and arithmetic (National Center for Improving Science Education 1989). Disadvantaged students therefore fall behind more advantaged students who are exposed to more rigorous academic subjects such as science and mathematics. At the secondary level, a large proportion of disadvantaged students decide to enroll or are placed in low-ability tracks or remedial programs that require few college preparatory courses (Oakes 1990a).

Each of these issues is addressed in the sections that follow.

Chapter Organization

In response to a request in 1983 by the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, the National Science Foundation (NSF) supported a number of projects to identify and develop systematic and objective indicators of the quality of precollege education in the United States. The RAND Corporation developed one such set of indicators and the National Academy of Sciences/National Research Council (NAS/NRC) developed another (Shavelson et al. 1989 and 1987, Raizen and Jones 1985, and Murnane and Raizen 1988). These efforts modeled the science and mathematics education system in terms of inputs, processes, and outcomes. Specifically, the RAND model, for example, identifies the following components as the major domains of the education system:

- *Outcomes*—student achievement, participation, and attitudes and aspirations;
- *Processes*—school quality, curriculum quality, instructional quality, and teaching quality; and
- *Inputs*—fiscal and other resources, teacher quality, and student background.

The RAND model and others agreed that the primary goal of instruction in science and mathematics is student learning. The most explicit student outcome, and one that can be tied most closely to schooling variables, is the knowledge, understanding, and skills gained by students—that is, student achievement in science and mathematics. The input and process variables selected for the models were those that have some causal relationship to student outcomes.

In addition, the RAND model recognized that the larger policy environment in which schooling occurs profoundly influences education in a variety of ways and must be taken into consideration in attempting to explain changes in the major components of schooling. Federal, state, and local policies largely determine the level and type of resources available to education, and these policies also influence who is allowed to teach, what content is taught, and even how it is taught.

Overall, this chapter follows the general framework of the RAND and NAS/NRC models. It emphasizes student outcomes and discussions of the major issues related to schools and curricula and teachers. The chapter ends by putting these components of the educational system model in a policy context. Specifically, it provides an overview of national and state-level education reforms undertaken recently and their status and success to date.

Students: Achievement, Interest, and Coursework

At the Education Summit in 1989, the President and the governors expressed concern about the country's ability to compete in the global economy and affirmed their commitment to equipping all U.S. children with a basic understanding of science, mathematics, and other subjects. A major result of this summit was the adoption of six ambitious education goals to be accomplished by the year 2000, three of them relating directly to science and mathematics achievement and literacy:

- American students will leave grades 4, 8, and 12 with demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography; and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.
- U.S. students will be first in the world in science and mathematics achievement.
- Every American adult will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

National Assessments of Educational Progress, 1970-90

Student achievement is measured by performance on national tests in special areas such as science, mathematics, and geography. For more than 20 years, the National Assessment of Educational Progress (NAEP)—conducted by the Education Commission of the States and, later, by the Educational Testing Service with the sponsorship of the National Center for Education Statistics—has been monitoring the educational achievement of American students and changes in that achievement across time. The results of the NAEP assessments have raised national concern about the level of student knowledge in science and mathematics. The latest NAEP results, for 1990, showed that many students appear to be graduating from high school with little of the science and mathematics knowledge required by the fastest growing occupations or for college work. For example, approximately half of the students in grade 12 graduating from school today appear to have an understanding of mathematics that does not extend much beyond multiplication and two-step problems (5th grade level) (Mullis et al. 1991b, p. 7). In addition, a series of international studies confirmed the low achievement level of U.S. students, showing that U.S. students in 8th grade mathematics—and even advanced 12th grade mathematics and science students—performed substantially below the levels of students in many other advanced countries.

In 1990, NAEP tested national samples of 9-, 13-, and 17-year-olds in science and mathematics. The 1990 results allowed NAEP to perform a 20-year trend analysis drawing on six assessments in science (1970, 1973, 1977, 1982, 1986, and 1990) and a 17-year trend analysis drawing on five assessments in mathematics (1973, 1978, 1982, 1986, and 1990). Also, for the first time, eighth grade student proficiency in mathematics was assessed in a Trial State Assessment Program that included 37 states, the District of Columbia, Guam, and the U.S. Virgin Islands (Mullis et al. 1991a and 1991b).

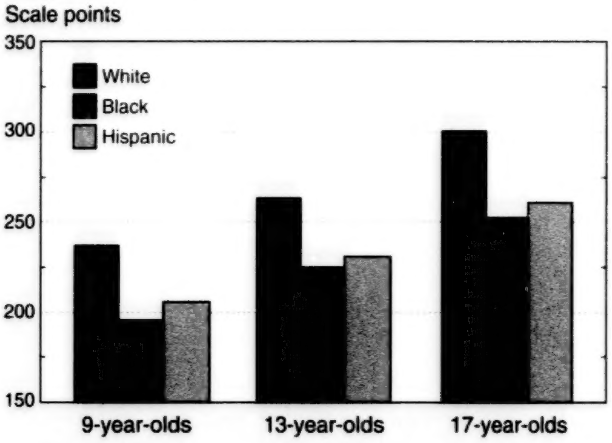
Science Achievement

NAEP assessments suggest that science achievement levels were about the same in 1990 as they were in 1970. Levels of performance in the six assessments varied, however, over the 20-year span. Average scores declined somewhat in the 1970s and increased in the 1980s. Yet among 17-year-olds—unlike 9- and 13-year-olds—science performance did not return to the level achieved in 1970. (See figure 1-1.)

Achievement by Minorities. Average science proficiency among blacks and Hispanics remained far below that of white students. However, from 1977 to 1986, the difference between minority and white students narrowed. For example, from 1977 to 1986, the difference between black and white 9-year-olds declined from 55 points to 36 points, from 48 to 38 points for 13-year-olds, and from 58 to 45 points for 17-year-olds. In 1990, the difference between white and black students remained about the same as in 1986. In all three age groups, gains by black students during the last 4 years were slightly less than those by whites. Among Hispanic students in all three age groups, gains in student achievement from 1986 to 1990 were nearly identical to those of white students. Figure 1-2 shows 1990 science proficiency by the three groups.

Achievement by Females. In 1990, the average science performance of females in all three age groups was lower than that of males, continuing a trend that had existed since the first assessment in 1970. (See figure 1-3.) The difference between males and females in science achievement remained about the same over the two decades. At age 17, the differences were greater than at ages 13 or 9. For 17-year-olds, trends in performance were comparable for males and females, with both showing declines from 1970 to 1982, followed by improvements from 1982 to 1990. For 13-year-olds, average scores of both males and females declined from 1970 to 1977 and then increased significantly from 1977 to 1990 to reach levels approximately equal to those in 1970. For 9-year-olds, the science proficiency of males in 1990 was at the same level as in 1970, but significant improvements for females from 1986 to 1990 raised their proficiency to a level somewhat higher than in 1970. (See appendix table 1-1.)

Figure 1-2.
U.S. average science proficiency, by race/ethnicity: 1990

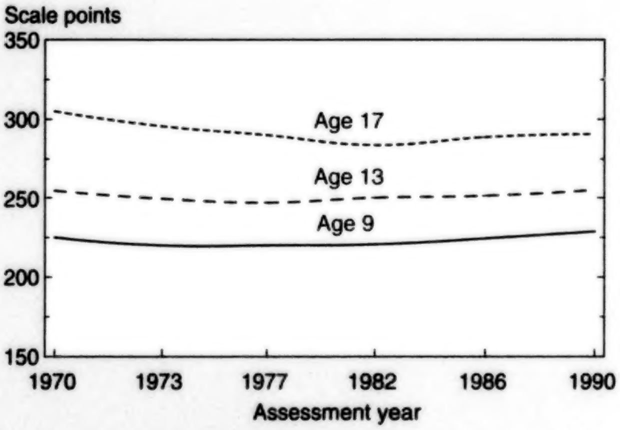


See appendix table 1-1. *Science & Engineering Indicators – 1991*

Level of Student Proficiency in Science

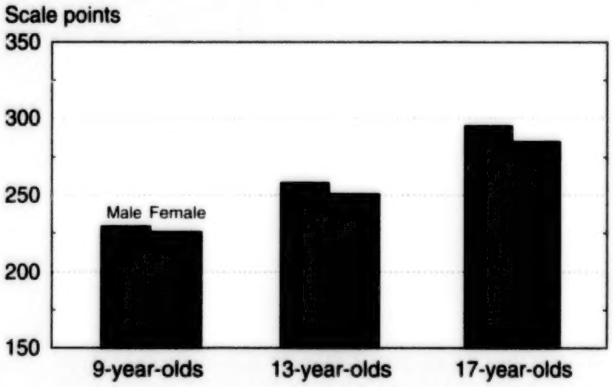
The NAEP science scale developed by the Educational Testing Service extends from 0 to 500. To aid interpretation of the scores, a group of science subject experts examined the test questions answered successfully by students scoring at each of five different levels. The experts described each of the levels in terms of what a student knows or can do in science. (See text table 1-1 and appendix table 1-2.)

Figure 1-1.
U.S. average science proficiency



See appendix table 1-1. *Science & Engineering Indicators – 1991*

Figure 1-3.
U.S. average science proficiency, by gender: 1990



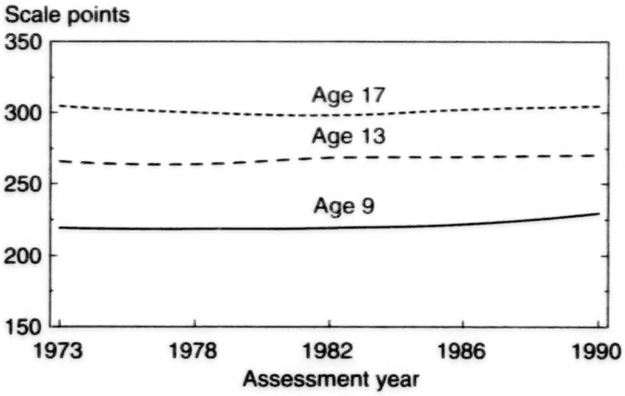
See appendix table 1-1. *Science & Engineering Indicators – 1991*

Text table 1-1.
Overall science proficiency: 1990

Level	Description	Age 9	Age 13	Age 17
		Percent		
150	Knows everyday science facts	97	100	100
200	Understands simple scientific principles	76	92	97
250	Applies basic scientific information	31	57	81
300	Analyzes scientific procedures and data	3	11	43
350	Integrates specialized scientific information	0	0	9

See appendix table 1-2. *Science & Engineering Indicators – 1991*

Figure 1-4.
U.S. average mathematics proficiency



See appendix table 1-4. *Science & Engineering Indicators – 1991*

In general, students performed well on questions about scientific facts (level 150), particularly if the questions involved information likely to be encountered in everyday experience. However, performance levels decreased as students encountered questions that asked them to analyze, evaluate, apply, or otherwise deal with more complex and detailed information (Mullis 1991b).

From 1977 to 1990, increasing percentages of 9- and 13-year-olds were able to understand simple scientific principles (level 200) and apply their scientific knowledge (level 250). (See appendix table 1-2.) However, 17-year-olds made virtually no progress in scientific proficiency at any level. Fewer females than males were able to perform at the highest two proficiency levels, and fewer than 1 in 10 17-year-olds demonstrated the highest level of science understanding.

In summary, some progress occurred from 1977 to 1990 in the percentages of 9- and 13-year-old students who performed at or above the three lower levels on the proficiency scale. However, 17-year-olds showed little progress at any scale level, and their ability to integrate specialized scientific information remained low.

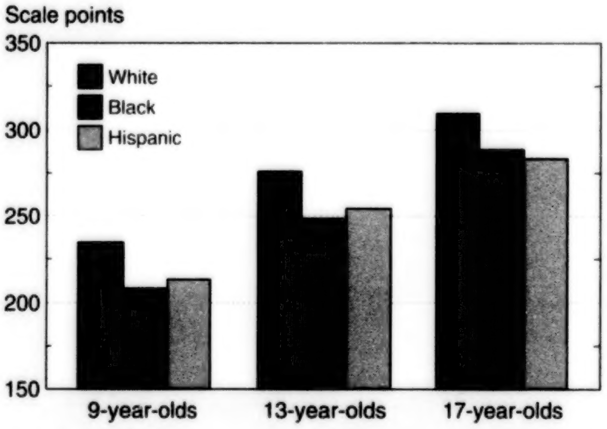
Mathematics Achievement

Trends in student achievement levels in mathematics were similar to trends in science achievement. Declines in the 1970s were followed by increases in the 1980s. By 1990, average mathematics proficiency among 9-year-olds was significantly higher than in 1973; among 13- and 17-year-olds, performance surpassed or returned to earlier levels. (See figure 1-4.)

Achievement by Minorities. Between 1973 and 1990, white, black, and Hispanic 9-year-olds all showed significant improvement in average mathematics proficiency, with much of this improvement occurring between 1986 and 1990. (See appendix table 1-4.) At age 13, black and Hispanic students made significant gains following 1973, with most of the improvement occurring between 1978 and 1986, while performance of white 13-year-old students remained relatively consistent across the assessments. Among 17-year-olds, blacks gained significantly, raising their scores about 19 points between the first assessment and 1990. Hispanic 17-year-olds made modest gains during the 1980s, while whites compensated for declines in the 1970s with small gains that returned them in 1990 to their original 1973 proficiency level.

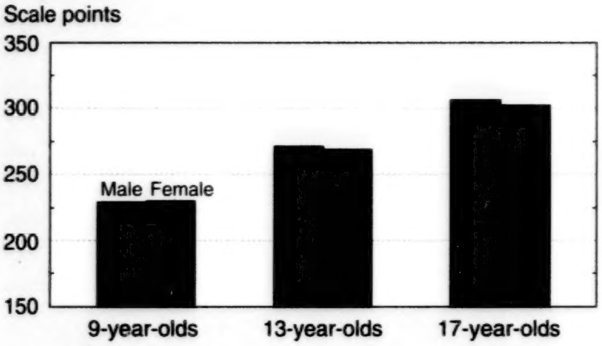
Thus, black students made significant progress at all ages, Hispanic students improved significantly at ages 9 and 13, and white students made significant gains at age 9. Although black and Hispanic students narrowed the gap shown in previous mathematics assessments between their performance and that of white students, these differences remained large in 1990 in all three age groups. (See figure 1-5.)

Figure 1-5.
U.S. average mathematics proficiency, by race/ethnicity: 1990



See appendix table 1-4. *Science & Engineering Indicators – 1991*

Figure 1-6.
U.S. average mathematics proficiency, by gender: 1990



See appendix table 1-4. *Science & Engineering Indicators – 1991*

Achievement by Females. Both female and male 9-year-olds made significant gains between 1973 and 1990, with most of the improvements occurring during the 1980s. (See appendix table 1-4.) Male and female 9-year-old students showed approximately the same level of mathematics proficiency in all of the assessments from 1973 to 1990. Thirteen-year-old males and females also showed improvements between 1973 and 1990, but their progress was gradual. Virtually no difference separated the levels of performance by the two groups in any of the assessments. Among 17-year-olds, the performance of males improved during the 1980s, but did not return to the level of 1973. Trends for females showed the same patterns as males, but their gains were somewhat larger during the 1980s. As a result, the slight performance gap between male and female students at age 17 nearly disappeared between 1973 and 1990. Furthermore, as shown in figure 1-6, the difference in scores between males and females at any age group is minimal.

Level of Student Proficiency in Mathematics

As in the science NAEP assessments, five levels of mathematics proficiency were established, in this case by a team of mathematics educators. (See text table 1-2 and appendix table 1-5.)

In the 1990 assessment, while the average 9-year-old student scored at about the expected level, scores for older students averaged substantially lower than the expected levels (Mullis, Owen, and Phillips 1990). The fact that the average student gained more between ages 9 and 13 (41 points) than between ages 13 and 17 (34 points) suggests that the U.S. mathematics curriculum facilitates more learning in the lower grades. (See appendix table 1-5.)

Significantly greater percentages of 9-year-olds showed proficiency in beginning skills and understanding and in basic operations and beginning problem-solving in 1990 than in previous assessments. (See appendix table 1-5.) These improvements in mathematics proficiency occurred in all three racial/ethnic groups and among both males and females. Gains were especially noteworthy among blacks. (See appendix table 1-6.)

Thirteen-year-olds as a group made significant gains in basic operations and beginning problem-solving: three-fourths performed at or above this level in 1990 compared to under two-thirds in 1978. Girls improved their proficiency, and by 1990 they performed at about the same level as boys. Large gaps in performance still separated whites and minorities in 1990, but minorities had made substantial gains. Compared to 1978, 20 percent more blacks and 21 percent more Hispanics were demonstrating proficiency in 1990 with basic operations and beginning problem-solving.

Of 17-year-olds in 1990, almost all (96 percent) were able to solve exercises involving basic operations and beginning problem-solving. This performance represented a significant improvement from 1978, when only 92 percent reached this level. Also, 56 percent of the 17-year-olds demonstrated a grasp of moderately complex procedures and reasoning, compared to 52 percent in 1978. Minority gains at this proficiency level were pronounced. Hispanics who demonstrated proficiency with moderately complex procedures increased from 23 percent in 1978 to 30 percent in 1990. The percentage of blacks virtually doubled—from 17 percent in 1978 to 33 percent in 1990. However, no group showed improvement in proficiency with multi-step problem-solving and algebra.

NAEP analysts found several encouraging aspects to the 1990 mathematics assessment findings. First, virtually all students showed gains in basic mathematics understanding, a result that was maintained and even improved slightly across the assessments. Second, all three ages showed significant increases in the percentages reaching the middle levels on the scale. Third, this phenomenon was most clearly evident in the trend results for black and

Text table 1-2.
Overall mathematics proficiency: 1990

Level	Description	Age 9	Age 13	Age 17
		Percent		
150	Simple arithmetic facts	99	100	100
200	Beginning skills and understandings	82	99	100
250	Basic operations and beginning problem-solving	28	75	96
300	Moderately complex procedures and reasoning	1	17	56
350	Multi-step problem-solving and algebra	0	0	7

See appendix table 1-5. *Science & Engineering Indicators – 1991*

Hispanic students at all ages. Finally, the trends by gender showed systematic and generally equivalent rates of progress, with females narrowing the gap that existed at age 17 and at the higher scale levels.

On the other hand, concerns continue because few students demonstrated proficiency at the highest level and because trends across time show no increase in the percentage of students learning more advanced material (Mullis et al. 1991b, p. 102).

State-Level Student Achievement. As part of the 1990 NAEP, states and territories could, on a voluntary basis, participate in the mathematics assessment of eighth graders.[1] The 1990 Trial State Assessment Program results showed that eighth grade students in 11 states scored an average of 270 points or higher. (See appendix table 1-7.) Eighth grade students in North Dakota attained the highest average score of 281, but North Dakota, Montana, Iowa, Nebraska, Minnesota, and Wisconsin had similar overall average proficiency. These six states also were the only ones where one-fifth or more of their eighth grade students demonstrated a grasp of problems involving fractions, decimals, percents, and simple algebra (level 300). Other states with relatively high average proficiency scores were New Hampshire, Idaho, Wyoming, Oregon, and Connecticut.

Considerable differences in overall average mathematics proficiency separated eighth grade students in the higher performing states from those in the lower scoring states. The higher performing states tended to have fewer students in cities with large populations, fewer students in free lunch programs, smaller percentages of black and Hispanic students, smaller percentages of students with both parents at home, and smaller percentages of students watching 6 or more hours of television each day. Higher performing states also tended to be in relatively less densely populated areas. The lower performing states tended to be in the Southeast.

Geography Achievement

As previously indicated, a national education goal identified by the President and the Nation's governors is demonstrated student competence and understanding in geography. In 1988, the NAEP Center of the Educational Testing Service tested high school seniors on their knowledge of four areas of proficiency in geography—location and place, skills and tools, cultural geography, and physical geography.[2] The assessment results showed that, overall, U.S. high school seniors had a weak grasp of geography.

Students were most proficient in *locating* major countries. For example, 87 percent could identify Canada on a world map; 87 percent also knew where the Soviet Union was located. But when they were asked to identify cities and land features, only 58 percent could locate Jerusalem on a regional map, and just 36 percent knew that Saudi Arabia borders on the Persian Gulf and the Red Sea. (Note that this study was conducted before the Gulf War.)

Students also did not do well on questions testing *geography skills and tools*. For example, when shown a dot map of population distributions in Europe, India, China, and Japan, almost one-quarter of the test-takers indicated that the map represented abundance of mineral deposits; only one-half recognized that the map represented population concentrations.

Students performed relatively well on questions involving *cultural geography*, particularly when the questions related to events and locations featured in the news. Thus, 79 percent appeared to understand the primary way to control acid rain, and 69 percent identified a risk to the environment resulting from the use of pesticides. Scores declined, however, when questions probed for more indepth understanding. Only 59 percent recognized the consequences of cutting down the rain forests, and only 53 percent identified a cause of the greenhouse effect.

Finally, in terms of physical geography (climate, weather, tectonics, and erosion), most students could recognize major features, but a surprisingly large minority could not. For example, only about two-thirds of the students knew the cause of the Earth's seasons, and just three-fifths recognized evidence of faulting in a cross-sectional drawing depicting a sharp fracture in the Earth's crust.

Achievement by Females and Minorities. Significant disparities in geography proficiency existed between white students and their black and Hispanic counterparts. Whites scored an average of 43 points above blacks and almost 30 points above Hispanics. The average performance of 12th grade males was about 16 points higher than that of their female classmates (Allen et al. 1990). Of the subject matter performance assessments conducted by NAEP in 1986 to 1988, the largest gap between average performance of males and females was in geography.[3]

Geography Coursework. As part of the 1988 geography assessment, students were asked to report on their geography coursetaking and the extent to which they had studied in class the topics covered in the assessment. The information received suggested two conclusions:

- Overall, geography was not emphasized in U.S. high schools.
- As the amount of time devoted to the study of specific topics increased, student performance in these topic areas also rose (Allen et al. 1990).

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[1] Altogether, 37 states, the District of Columbia, Guam, and the U.S. Virgin Islands participated in the mathematics assessment.

[2] The 1988 geography assessment (Allen et al. 1990) was based on a national probability sample of more than 300 public and private schools across the United States.

[3] National assessments were conducted during 1986-88 in reading, mathematics, science, U.S. history, civics, and geography.

The first conclusion is borne out by an analysis of high school transcripts (Westat 1988). Analysis showed that only 16.5 percent of all high school graduates had earned at least 0.5 credits in geography in 1987, approximately the same percentage of graduates as in 1982. Also, in a survey conducted in 1988, only nine states reported that they required students to take a geography course before they graduated from high school (CCSSO 1988).

International Context of Achievement

International comparisons of science and mathematics achievement have consistently found that students in Japan, Korea, and Hong Kong scored far above U.S. students in middle school or high school (McKnight et al. 1989 and Lapointe, Mead, and Phillips 1989). Studies examined differences in school coverage of the test topics and found that Asian countries covered more of these subjects in school than did the United States. However, not all of the differences in student performance could be attributed simply to classroom coverage of test topics. Other factors were also found to be important, as described below.

A recent study assessed children's mathematics achievement in the first and fifth grades in three large metropolitan areas: Sendai, Japan; Taipei, Taiwan; and Minneapolis, Minnesota.[4] The researchers tested students' cognitive abilities, observed them and their teachers in classrooms, and interviewed the children and their mothers and teachers.

The researchers examined the children's achievement in relation to three major factors: their intelligence, their experiences in school, and their experiences at home. Based on a battery of cognitive tests, the researchers found no evidence that children in the two Asian cities were more intelligent than those in Minneapolis. They did find, however, that Minneapolis children were at a relative disadvantage in mathematics as early as the first grade. Because these differences in performance appeared so early in children's schooling, researchers concluded that factors at home as well as at school must be responsible for them. Upon further analysis of the study results, the researchers identified several factors that appeared to underlie the relatively poor mathematics performance of Minneapolis children; these are described below.

Time Devoted to Academic Activities. There were significant differences in the amounts of time given to academic activities in classrooms in the two Asian cities and in Minneapolis. The percentage of time so devoted in Minneapolis classrooms was 64 percent, compared with 87 percent in Sendai classrooms and 92 percent in those in Taipei. Minneapolis fifth graders averaged 20 hours a week on classroom academic activities; fifth graders in the two Asian cities spent 33 and 40 hours, respectively, on such activities.

In Minneapolis classrooms, more of this academic time was dedicated to reading and language arts than to mathematics.[5] In the first grade, 2.7 hours were spent on mathematics instruction in Minneapolis compared to 4.0 hours in Taipei and 5.8 hours in Sendai classrooms. In the fifth grade, 3.4 hours of mathematics were taught in Minneapolis classrooms compared with 11.7 hours in Taipei and 7.8 hours in Sendai. Thus, on average, children in the two Asian cities spent over twice the amount of time on mathematics in the classroom as did Minneapolis children. (See figure O-13 in Overview.)

Mothers' Goals and Standards for Academic Achievement. Unlike the mothers surveyed in the two Asian cities, Minneapolis mothers—although interested in their children's education—were less prone to require their children to demonstrate high levels of academic achievement. Minneapolis mothers generally became dissatisfied only when their children's school performance was well below average. On the other hand, academic performance dominated the attention of mothers in the two Asian sites, although they focused their concerns on different aspects of achievement. Sendai mothers, recognizing that grades have little relevance in Japan in gaining admission to prestigious schools, were most concerned that their children learn the information necessary to pass entrance examinations. For their part, mothers in Taipei viewed high grades as the primary measure of success in elementary school.

Children's Perceptions of Their Own School Achievement. In self-ratings of how well they were doing in their mathematics schoolwork, Minneapolis children tended to give themselves the highest ratings, but they actually did less well on achievement tests of mathematics ability than the children in Taipei and Sendai. In ratings of their mathematics achievement in school, Sendai and Taipei fifth graders tended to rate themselves as near average, while Minneapolis fifth graders gave themselves the highest ratings.

In this regard, some of the strongest correlations obtained in the study were between the children's ratings of how good they thought they were in a subject and how much they liked the subject. Children clearly liked the subjects in which they thought they were doing well and disliked the subjects in which they thought they were doing poorly. Why did the children in Minneapolis like mathematics and believe that they were good at it? The researchers concluded that the answer seemed to be that the mathematics curriculum in Minneapolis schools was easier than those of the two Asian cities. Analyses of mathematics textbooks used in the three cities seemed to support this conclusion. For example, mathematics concepts tended to be introduced somewhat earlier in Sendai than in Minneapolis schools.

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[4] This study was conducted with 1,440 students attending elementary schools in the three cities (240 first graders and 240 fifth graders in each city). The children were selected from 20 classrooms at each grade in each city and constituted a representative sample of children from these classrooms. In a followup study, first graders were studied again when they were in the fifth grade. The children were tested with achievement tests in mathematics and reading constructed specifically for this study, the children and their mothers were interviewed, the children's teachers filled out a questionnaire, and interviews were held with the principals. In the followup study, achievement tests were administered, and the children and their mothers were interviewed. For more information, see Stevenson and Shin-Ying (1990).

[5] These same priorities are favored by American parents who may not appreciate the importance of mathematics in their children's later education and work. In interviews, American mothers cited reading as the subject that should receive increased emphasis in school.

Roles of Mothers. The researchers gained the impression that Minneapolis mothers were dedicated to their children's development during their preschool years but that they abdicated some of their responsibilities to the teacher once the children entered school. This tendency was the opposite of what occurred in homes in the two Asian cities. In all three cultures, the preschool years were a time of freedom and indulgence, and there was no great concern about the child's learning academic skills. But from the time that the child entered school in Taipei and Sendai, the child, the mother, and the teachers began the serious task of education. The more years the child was in school, the stronger the emphasis on academic activities became. On the other hand, for the children in Minneapolis, the transition into elementary school was less notable—from the time that they entered school, their lives were not encumbered by strong demands for academic excellence or homework, and there was little increase in demands during the 6 years of elementary school.

Ability Versus Effort in Student Accomplishment. Minneapolis mothers identified individual ability as one of the most important factors in academic performance. In contrast, mothers in the two Asian cities emphasized effort over ability in academic achievement. In other words, parents of schoolchildren in Minneapolis held that children of high ability need not work hard to achieve and that children of low ability would not achieve regardless of how hard they worked. The Asian parents, on the other hand, considered effort and self-discipline essential to accomplishment.[6] The researchers concluded that when parents believed that success in school depended more on ability than hard work, they were less likely to foster participation in activities related to academic achievement, i.e., requiring that their children spend time on homework and participate in after-school scholastic activities.

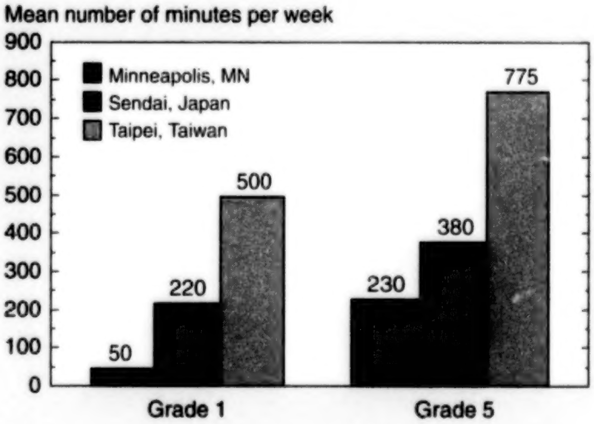
Not surprisingly, the children in the two Asian sites spent considerably more time on homework at both the first and fifth grade levels than the Minneapolis schoolchildren (Stevenson et al. 1990). According to estimates made by mothers of the schoolchildren, Sendai first graders spent more than 4 times as much time doing homework as first graders in Minneapolis; children in Taipei spent 10 times as much as the Minneapolis children. At the fifth grade level, Sendai children still spent over 50 percent more time and Taipei children spent over 336 percent more time than did their Minneapolis counterparts. (See figure 1-7.)

Top Mathematics Test Scorers

Although overall trends in science and mathematics interests and coursetaking are useful, the science and engineering (S&E) preferences of talented high school students are particularly significant because these individuals represent a major source of future scientists and engineers. This section examines data on the proportion of top-scoring high school seniors (i.e., those scoring above the 90th percentile on the quantitative Scholastic Aptitude Test—SAT) who intend to pursue a college major in science, mathematics, or engineering. Although many high school seniors change their major field of study after they enter college, the SAT data serve as an approximation of how well the S&E professions are attracting high school seniors (Grandy 1990a, p. 4). Generally, the decision not to major in an S&E field means that students will not continue to acquire the skills necessary to move into these fields at a later time.

Of high school seniors who scored above the 90th percentile on the SAT quantitative exam in 1990, about 46 percent intended to major in S&E fields in college. (See figure 1-8.) By gender, 55 percent of all top-scoring males and 38 percent of top-scoring females planned to pursue an S&E major. Engineering was the S&E field selected by the largest proportion of top-scoring students regardless of gender, accounting for one-fifth of the total.

Figure 1-7.
Mothers' estimates of time spent by their children on homework



SOURCE: H.W. Stevenson and L. Shin-Ying, *Contexts of Achievement*, Monographs of the Society for Research in Child Development, Serial No. 221, Vol. 55, Nos. 1-2 (1990).

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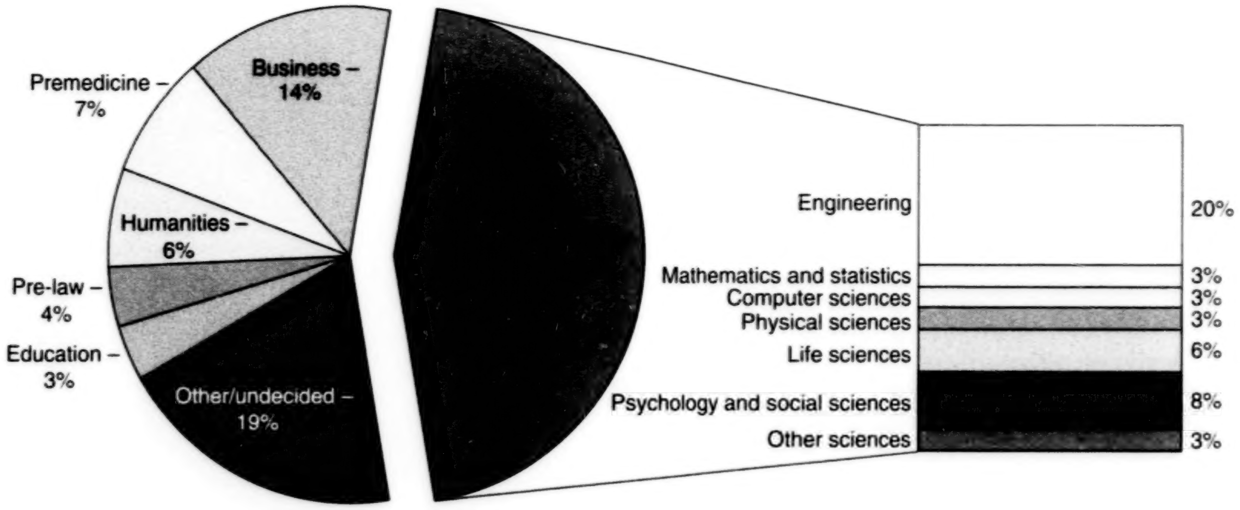
[6] The researchers found no evidence in schools in Japan and Taiwan of grouping of students within grades according to level of ability nor were there special education teachers or special classes for slow learners. The researchers concluded that the Asian teachers sincerely believed that all children at the elementary level were capable of mastering the curriculum and that academic success was within the grasp of all children if they applied themselves to their schoolwork (Stevenson et al. 1990).

Figure 1-8.
Intended majors of high school seniors scoring above the 90th percentile on the mathematics SAT: 1990



See appendix table 1-8.

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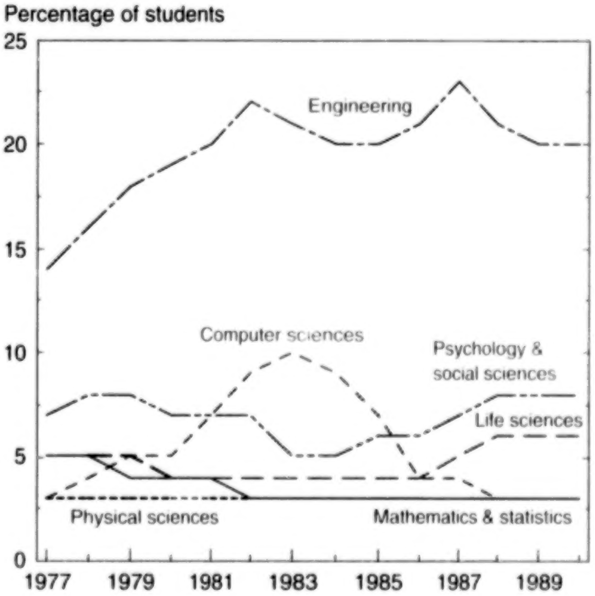
Overall, the proportion of top-scoring students intending to major in S&E fields increased by 6 percentage points from 1977 to 1990. (See appendix table 1-8.) From 1977 to 1987, interest in an engineering major increased, rising from 14 to 23 percent. Concurrently, interest in majoring in science fields declined until 1986, from 27 to 23 percent. Beginning in 1986, however, these trends began to reverse: interest in science and mathematics grew while interest in engineering dropped slightly. A precipitous drop occurred in the number intending to major in the computer sciences; interest in this field declined from a peak of 10 percent in 1983 to 3 percent in 1990.(See figure 1-9.) In non-S&E fields, business grew the most significantly, from 7 percent in 1977 to 15 percent in 1989.

Over these years, fewer top-scoring examinees indicated that they were undecided about their major field. In 1977, more than one-third of these students said that they were undecided about their college major, compared with 29 percent in 1984, and 19 percent in 1990. Thus, the growth in interest in some fields reflects a greater tendency for students to choose a field at all.

Disaggregating the data by gender and racial/ethnic group reveals that over this period groups traditionally underrepresented in engineering were showing increasing interest in this field. (See appendix tables 1-9, 1-10, 1-11, and 1-12.) For example, the proportion of top-scoring black females intending to major in engineering doubled from 7 percent in 1977 to 14 percent in 1990. Similarly, black males interested in an engineering major increased from 21 to 34 percent over the same period. The comparable portion of white females rose from 5 percent in 1977 to 9 percent in 1990.

Figure 1-9.
Trends in intended majors of high school seniors scoring in the 90th percentile on the mathematics SAT



See appendix table 1-8. *Science & Engineering Indicators – 1991*

S&E Interests of Secondary School Students

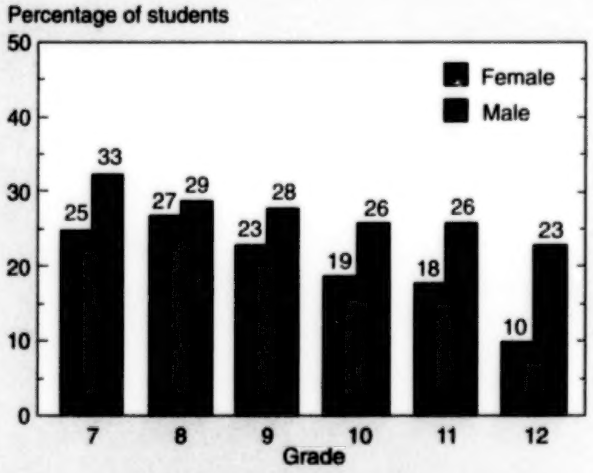
Why do some American secondary students develop a preference for a career in science, mathematics, or engineering (SME) and pursue courses toward that objective? The Longitudinal Study of American Youth (LSAY) was launched in response to this question, to determine the relative contributions of family, peers, teachers, classroom experiences, and school climate in shaping student preferences.[7]

Each semester, students were asked to list the two occupations they thought they would most likely be pursuing at age 40. Students who chose scientist, mathematician, engineer, or a graduate-educated medical professional as their first or second choice were classified as having a preference for an SME career.

Nearly 30 percent of seventh grade students—33 percent of males and 25 percent of females—expressed a preference for an SME career, but these percentages declined steadily throughout the remaining middle school and high school years. (See figure 1-10.) Moreover, the percentage of female students expressing a preference for an SME career declined at a faster rate than that for male students. By the 12th grade, fewer than 1 in 4 male students and only about 1 in 10 female students expressed an interest in an SME career (Miller et al. 1990).

Figure 1-10.

High school student preferences for careers in science, mathematics, or engineering: 1987-90



SOURCE: J.D. Miller, et al., *Student Expectations of Careers in Science, Mathematics, or Engineering: Some Models from the Longitudinal Study of American Youth,* draft report to the LSAY National Advisory Committee (DeKalb, IL: Northern Illinois University, 1990).

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The LSAY researchers found that the selection of an SME career in secondary school was a complex decision reflecting a wide array of influences, including

- *Parent encouragement* and pressure to achieve academically, to go to college, and to do well in mathematics;
- *Parental resources,* which reflect the level of parent education, availability of home learning resources, and employment of either parent in science or engineering;
- *Student gender;* and
- *Persistence in mathematics*—during high school in particular, persistence in advanced mathematics became a major predictor of SME career expectations.

The relative impact of these influences changed over time. For example, during the middle school years, students were uncertain about longer term career choices, and the expectation of an SME career was weakly associated with parent encouragement and parental resources.

In high school, as more students began to arrive at firmer conclusions about their career choices, parent encouragement, student gender, and persistence in mathematics all became increasingly important predictors of an expected career in SME. By grade 10, the influence of parent encouragement was evidenced by an increased likelihood of higher grades in science and mathematics courses and persistence in advanced mathematics courses. Students with higher levels of parental resources were significantly more likely to enroll in advanced mathematics courses, to participate in informal science education, and to earn higher grades in science courses.

Parent encouragement was especially important in the formulation of career expectations of high school girls. This result suggested that among families with higher levels of resources, males might tend to see an SME career as a natural and reasonable choice, but females needed more encouragement to choose a career in a traditionally male-dominated field.

Course Enrollment in Secondary Schools

Recent research demonstrates the critical role that enrollment in particular courses in high school has on college attendance and completion rates among students, including minority and poor students. Accordingly, increased course requirements in a core of academic subjects was a central theme of educational reforms in the 1980s. However, a report that reviewed the coursetaking patterns of students between 1982 and 1987 concluded that while some states succeeded overall in strengthening their core high school curriculum, "the coursetaking requirements leave room for improvement in closing the gap among subgroups at all levels and in reducing differences that result from disparate social and economic backgrounds" (ETS 1989, p. 17).

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[7] LSAY was a national probability sample of 6,000 students in 50 middle schools and 50 high schools. Students were followed in each year of their middle school and high school years and were administered science and mathematics achievement tests each fall. Questionnaires were filled out by each student in the sample to obtain course evaluation and attitudinal data. In addition, approximately 1,000 teacher reports were collected each year on all science and mathematics courses taken by students in the sample, and telephone interviews were conducted each spring to obtain family background information on each LSAY student. LSAY was conducted at the Public Opinion Laboratory from fall 1987 to fall 1990.

Enrollment Trends Over Time. Over the 25 years between 1965 and 1990, course enrollments in high school science and mathematics increased significantly following an initial decline. These trends reflected two distinct periods in American education. From the late 1960s until the late 1970s, the high school curriculum was undergoing increasing liberalization, resulting in a system in which students gained greater choice about what they studied. Subsequently, for several years after the late 1970s, high schools continued to offer a wide variety of courses, but students began to concentrate their coursetaking in more traditional academic courses. More substantial growth in academic coursetaking occurred after the early 1980s, when the states and local education agencies increased their graduation requirements to encourage achievement of academic excellence (Tuma et al. 1989).

As a result of these trends, the number of credits earned in science and mathematics was higher in 1987 than in 1969. (See text table 1-3.) The courses contributing most heavily to this increase were generally more advanced and core courses.[8] For example, in science, biology and chemistry had the most significant increases in credits earned. By 1987, nine-tenths of all high school graduates had taken a course in biology, and just under half (45 percent) had taken chemistry. Physics enrollment also increased, albeit not so dramatically: by 1987, one in five students took physics. (See figure 1-11.) In mathematics, the courses showing the greatest increases in credits earned between 1982 and 1987 were geometry and algebra 2. (See figure 1-12.)

Text table 1-3.
Average number of course credits earned by high school graduates in science and mathematics

	Science credits	Math credits
1969	2.23	2.47
1975-78	2.26	2.35
1979-81	2.18	2.44
1982	2.17	2.55
1987	2.51	3.02

SOURCE: J. Tuma, A. Gifford, D. Harde, E.G. Hoachlander, and L. Horn, *Course Enrollment Patterns in Public Secondary Schools, 1969 to 1987* (Berkeley, CA: MPR Associates, Inc., 1989).

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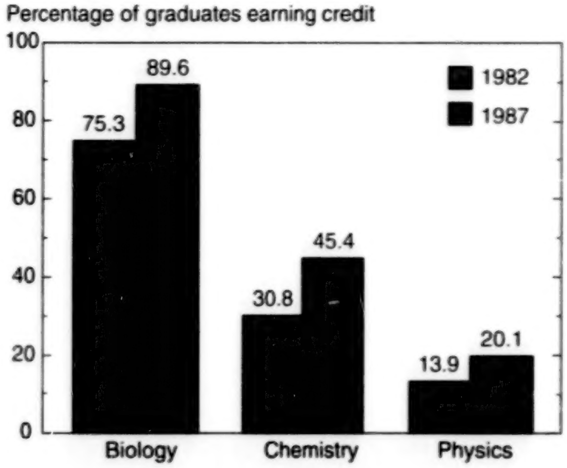
Figure 1-11.
High school 1982 and 1987 graduates who earned science course credit



SOURCE: Westat, Inc., *Tabulations: Nation At Risk Update Study as Part of the 1987 High School Transcript Study* (Rockville, MD: 1988).

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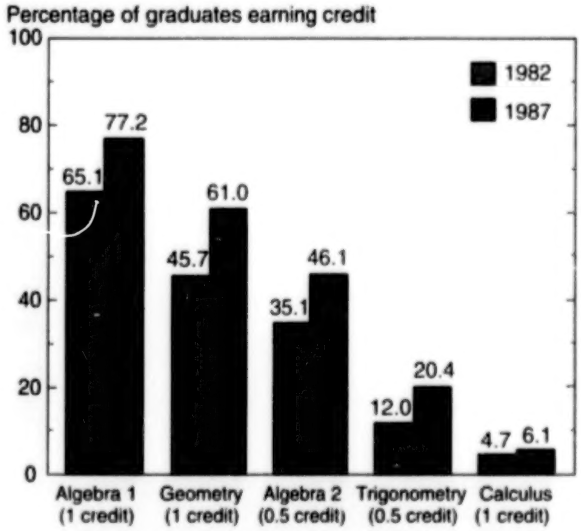
In the 1990 NAEP science assessment, general science and biology were the only courses reported by a majority of 17-year-olds as having been studied for at least 1 year. (See appendix table 1-13.) Only 1 in 10 of the students reported taking physics for a year or more.

Figure 1-12.
High school 1982 and 1987 graduates who earned mathematics course credit



SOURCE: Westat, Inc., *Tabulations: Nation At Risk Update Study as Part of the 1987 High School Transcript Study* (Rockville, MD: 1988).

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[8] These data were drawn from a national sample of transcripts from four studies of high school students: the Educational Testing Service's Study of Academic Prediction and Growth (1969), the National Longitudinal Survey of Labor Force Experience—Youth Cohort (1975-78 and 1979-82), High School and Beyond (1982), and the NAEP transcript study (1987).

Compared with 1982, significantly higher percentages of students reported having studied physical science, earth and space sciences, biology, and chemistry, with the largest increases occurring in chemistry and biology. The national trends were similar for both males and females and for white, black, and Hispanic students.

In mathematics, the NAEP assessment showed that higher percentages of 17-year-old students took upper-level courses such as algebra 2 in 1990 than in 1978. (See appendix table 1-14.) Thus, in 1990, more students completed the sequence of algebra 1, geometry, and algebra 2 than in 1978. Only relatively small numbers of 17-year-old students—6 percent in 1978, 8 percent in 1990—reported having taken precalculus or calculus.

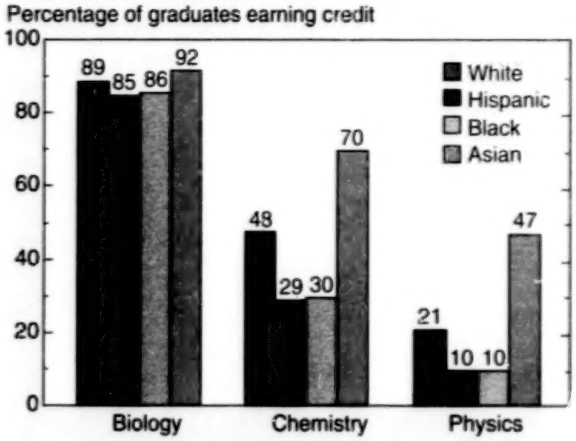
State-Level Enrollment. A study conducted in the 1989/90 school year by the Council of Chief State School Officers (CCSSO) indicated that secondary enrollment in biology had increased, while enrollment in chemistry and physics had essentially leveled off. The CCSSO study also found substantial differences in enrollment in secondary science courses among the states.[9] Chemistry, considered a gatekeeping course for continuing studies in science fields, ranged in enrollments from 26 percent (Idaho) to 62 percent (Connecticut). (See appendix table 1-15.) Eighteen of thirty-eight states had higher rates of enrollment in chemistry than the national average (45 percent). In first year physics, the state percentages varied from 10 percent in Oklahoma to 36 percent in Connecticut.

In mathematics, the CCSSO data also showed small continuing increases in three levels. By 1989/90, the estimated percentage of students taking algebra 1 had increased to 81 percent, algebra 2 increased to 49 percent, and enrollment in calculus classes increased to 9 percent. (See appendix table 1-16.) One of the important findings from the CCSSO study is the relatively small proportion of high school graduates—fewer than one-half—who took algebra 2. The state percentages of high school graduates who took algebra 2 varied from 29 percent in Wyoming to 65 percent in Montana.

Enrollment by Females. Differences by gender in enrollments in both science and mathematics decreased over time. (See appendix tables 1-17 and 1-18.) In mathematics, males earned an average of 0.5 credits more than females in 1969, but by 1987 this difference had narrowed to 0.09 credits. Only slight differences separate males and females in the number of science credits earned. However, coursetaking patterns differ by gender. For example, in 1987, females tended to earn more credits in biology, and males tended to earn more credits in physics.

Enrollment by Minorities. Asian students earned consistently more science and mathematics credits than any other racial/ethnic group, especially in chemistry and physics. (See figures 1-13 and 1-14.) Whites also tended to earn more science credits than black or Hispanic students. Racial/ethnic differences were not so pronounced in biology. (See appendix table 1-17.)

Figure 1-13.
High school 1987 graduates who earned science course credit, by race/ethnicity



SOURCE: J. Tuma, A. Gifford, D. Harde, E.G. Hoachlander, and L. Horn, *Course Enrollment Patterns in Public Secondary Schools, 1969 to 1987* (Berkeley, CA: MPR Associates, Inc., 1989).

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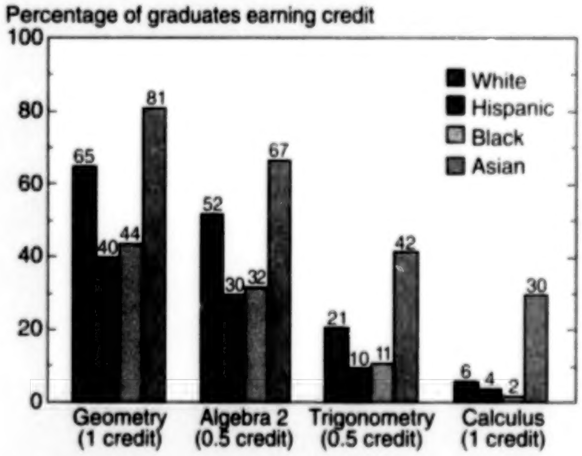
In mathematics, the more advanced the course, the more pronounced the difference in the number of credits earned by Asian students compared with other racial/ethnic groups. Between 1982 and 1987, the largest increases in the number of mathematics credits earned by Asians were in calculus and algebra. White students showed large increases in geometry; blacks, in geometry and algebra; and Hispanic students showed large

Figure 1-14.
High school 1987 graduates who earned mathematics course credit, by race/ethnicity



SOURCE: J. Tuma, A. Gifford, D. Harde, E.G. Hoachlander, and L. Horn, *Course Enrollment Patterns in Public Secondary Schools, 1969 to 1987* (Berkeley, CA: MPR Associates, Inc., 1989).

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increases in the number of basic mathematics, algebra, and geometry course credits earned. (See appendix table 1-18.)

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[9] Data on course enrollment were reported by 38 states.

School and Curriculum

This section examines factors that shape how students are taught—for example, how often they study a subject, how long they spend during these sessions, what activities predominate during the classes, and what "track" they are in. Beginning in grade 8, U.S. students are usually tracked into one of four kinds of mathematics classes (remedial, general, enriched, advanced), and students' achievement typically depends directly on the topics covered in these classes (Hafner and Horn in press, p. 48). In particular, this section emphasizes how tracking and related factors affect opportunities and access for groups underrepresented in science and mathematics.

Classroom Activities

As part of the 1990 NAEP assessments, 9-year-old students were asked about their participation in several science activities in the classroom. These inquiries reflected research indicating that students learn science more effectively when they use scientific instruments and materials. According to the research, students are likely to begin to understand the natural world if they work directly with natural phenomena, using their senses to observe and using instruments to extend the power of their senses. The NAEP assessments also asked 17-year-old students about their classroom experience in mathematics. These questions reflected efforts to focus on mathematical problem-solving and logical/reasoning skills, learning to communicate mathematically, and making connections between the mathematics students study and its applications in other disciplines and activities (Mullis et al. 1991b).

The 1990 assessment showed a larger percentage of 9-year-olds using several types of scientific instruments (microscopes, calculators, and thermometers) than in 1977. However, the percentage who had done experiments with living plants decreased significantly, and the percentage of students who had used a scale or done experiments with batteries did not change significantly.

In mathematics, an attempt was made to find out the proportion of 17-year-olds who were engaged in active mathematics learning (for example, participating in discussions and making reports or completing projects), rather than passive activities (such as listening to the teacher and watching him or her do problems on the board). The results, termed "disappointing" by the NAEP researchers, showed that activities generally considered more student-centered remained far less prevalent than listening to teacher explanations, watching the teacher work problems, or taking tests. (See appendix table 1-19.) For example, most students reported that they "often" listened to a teacher explain a mathematics lesson, watched a teacher work mathematics problems on the board, and took mathematics tests, while only a small fraction of them reported that they often made reports or did projects in mathematics (Mullis et al. 1991b).

The NAEP results agreed with earlier surveys. When elementary and middle school teachers were asked in a 1985-86 survey to indicate what took place during their most recent science and mathematics classes, responses indicated that most of the lessons included lecture and discussion (Weiss 1987). Use of hands-on activities was far less frequent and became less so the higher the grade level. Particularly in science, use of hands-on activities was much more common in elementary science than in middle school classrooms.

In the National Education Longitudinal Study of 1988 (NELS:88),[10] 59 percent of the eighth grade students were in science classes where their teachers said that experiments were conducted at least once a week; 41 percent attended classes where teachers said that experiments were seldom conducted. (See appendix table 1-20.)

Other studies have examined how long classroom lessons tend to last and how much time teachers spend in total on a subject during a week. In the 1985-86 National Survey of Science and Mathematics Education, elementary teachers were asked to indicate the approximate number of minutes typically spent teaching science, mathematics, social studies, and reading. Only one-half of all third graders had science lessons on a frequent basis, and for those who did, teachers reported devoting an average of only 18 minutes a day to science instruction. These teachers spent twice as much time on mathematics instruction and four times as much on reading instruction. In grades 4-6, an average of 29 minutes per day was spent on science lessons, compared with 52 minutes on mathematics and 63 minutes on reading.

In the 1987/88 Schools and Staffing Survey (SASS), elementary teachers were asked how much time they spent per week teaching four core subjects—science, mathematics, social studies/history, and English/language arts. State-by-state data showed that the class time spent on science in grades 1-3 varied from 1.3 hours per week in Rhode Island to 3.5 hours in Texas and, in grades 4-6, from 2.2 hours per week in Utah to 4.1 hours in New Hampshire. (See appendix table 1-21.)

The time spent on mathematics/arithmetic in grades 1-3 varied from 4.2 hours per week in Ohio to 6.0 hours

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[10] NELS:88 is a longitudinal survey sponsored by the U.S. Department of Education's National Center for Education Statistics. It surveyed 24,599 students in grade 8 and their parents, teachers, and school administrators. The student sample was selected from 1,035 public and private schools representing each of the 50 states and the District of Columbia. The students were administered tests of their knowledge of eighth grade science and mathematics and other subjects. The sampled subjects are being followed every 2 years through college and beyond to learn about their progress in school, their aspirations, their employment, and factors that affect their ability to complete their education.

Science and Mathematics Curriculum Related to Student Learning and College Attendance

Several recent studies suggest that enrollment in certain courses has implications well beyond simple exposure to a certain body of knowledge. One of these studies, the LSAY, found a strong positive relationship between 12th grade students' ability to engage in abstract problem-solving and coursetaking in advanced mathematics (Miller et al. 1990). Specifically, the LSAY found that students who were enrolled in calculus courses had a much greater ability to solve abstract problems than those who were enrolled in "low math" courses. The same study found a similar result, although less pronounced, for science proficiency and student coursetaking: students who took physics were much better at understanding scientific systems or interacting processes than students who took "low science" courses.

Another longitudinal study of eighth grade students, NELS:88, found that students who were in an algebra or other advanced mathematics class were almost five times as likely as students in a regular mathematics class (in which fractions were taught as a major topic) to be proficient at higher level mathematics problem-solving. The same study found that students who were in science classes where experiments were conducted at least once a week had the highest scores on science achievement tests, while students who were in classes that only conducted experiments once a month or less had the lowest scores (Hafner and Horn in press).

Analyzing data from the High School and Beyond survey, a third study found that the best determinant of future college attendance was enrollment in high school geometry. Overall, a much lower proportion of minorities than whites attended college within 4 years of high school graduation. Among students who took geometry, however, this difference disappeared: 80 percent of black students in this group attended college, along with 82 percent of Hispanic students and 83 percent of whites. Even for students at the poverty level, taking geometry halved the gap in college attendance.

Fewer than one-third of students with no algebra or geometry in high school attended a college within 4 years of graduation, and only about 15 percent attended a 4-year college. (See text table 1-4.) By contrast, among students who took both algebra and geometry (about one-third of the high school population), more than four-fifths attended college—including community and junior college—and two-thirds attended a 4-year college within 4 years of graduation. Other high school courses associated with college attendance (but less so than geometry) were 1 year of laboratory science and 2 years of foreign language (Pelavin and Kane 1990).

The above information notwithstanding, analyses of student coursetaking cannot establish causal relationships for either student learning or college attendance. It cannot be determined, for example, whether students with higher proficiency are more likely than others to seek out rigorous courses or whether the courses themselves strengthen proficiency.

Text table 1-4.
High school 1982 graduates who attended college within 4 years of graduation, by mathematics courses taken

Mathematics courses taken	Total	Within 4 years attended . . . Any college	A 4-year college
	Percent		
All graduates	100.0	55.4	36.9
No advanced mathematics	40.0	30.6	14.8
Algebra only	24.9	57.2	32.1
Algebra and geometry	34.9	82.6	65.6

SOURCE: S. Pelavin and M. Kane, *Changing the Odds: Factors Increasing Access to College* (New York: College Entrance Examination Board, 1990).

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in the District of Columbia and, in grades 4-6, from 3.8 hours in Montana to 6.0 hours in Mississippi.

Tracking has a fundamental impact on what students study and thus what skills they have an opportunity to master, particularly in mathematics. The NELS:88 study found that approximately 29 percent of public school eighth graders reported attending an algebra or other advanced mathematics class, 17 percent attended general mathematics along with an algebra or accelerated program, 47 percent attended only general mathematics class, and 7 percent attended some sort of remedial class. Almost all of the eighth graders reported receiving science instruction.

Barriers to Minority and Impoverished Students

Tracking programs—whether advanced or remedial—have a profound effect on the type of classroom instruction individuals receive. Those students who have shown an aptitude for mathematics are often given instruction in algebra and other more advanced subjects in grade 8.

Those who have not performed as well frequently have no access to mathematics classes that stress higher order thinking; instead, they are relegated to classes where learning computations involving fractions predominates. Evidence from the NELS:88 survey suggests that unequal opportunities to learn mathematics exist at the eighth grade level (Hafner and Horn in press).

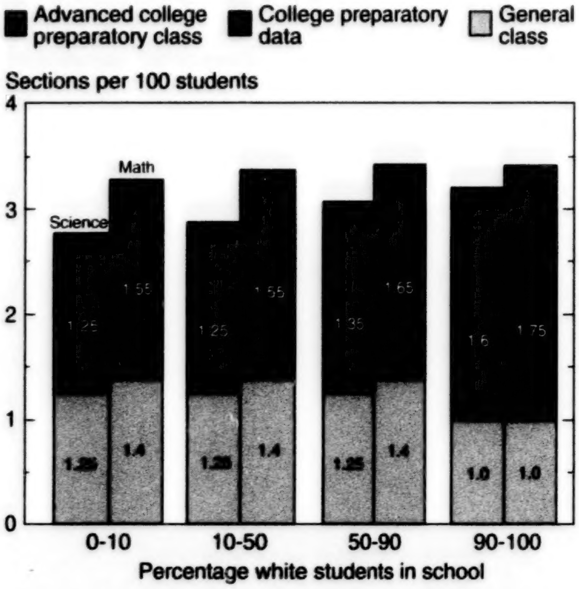
The NELS:88 survey also found that blacks, Hispanics, Native Americans, and low socioeconomic status (SES) eighth grade students were all twice as likely as white students to be in remedial mathematics classes. Slightly fewer than half of low SES students were in mathematics classes where algebra was taught as a major topic compared with 75 percent of high SES students; 79 percent of low SES students and 52 percent of high SES students were in classes that emphasized the teaching of fractions as a major topic. Asian and white students were far more likely than blacks, Hispanics, or Native Americans to be in classes where algebra was a major topic. (See appendix table 1-22.)

In science, only about 49 percent of low SES students were in classes where experiments were conducted at least once a week, compared with 72 percent of high SES students. Asian and white students were more likely than black, Hispanic, or Native American students to be in science classes that conducted experiments once a week or more. (See appendix table 1-20.)

Another recent study (Oakes 1990a) showed that high percentages of minorities faced several barriers to science and mathematics opportunities in secondary schools. First, their access to high-track science and mathematics classes diminished as the minority enrollment at their school increased. Second, minority students who attended racially mixed schools were more likely than their white peers to be placed in low-track classes. Third, minorities tended to have less access to "gatekeeping" courses at their schools, that is, courses that are especially important in qualifying students for college-level work in science and mathematics.[11]

Minority Enrollment. The first of these barriers is demonstrated in figure 1-15, which shows the number of class sections in science and mathematics classified by the content and level of the class (general, college preparatory, or advanced college preparatory). Generally, as the proportion of minority students at a school increased, the relative proportion of college preparatory or advanced course sections decreased.

Figure 1-15.
Sections of science and mathematics classes in high schools, by school racial composition: 1986



SOURCE: J. Oakes, *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science* (Santa Monica, CA: The RAND Corporation, 1990).

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Low-Track Classes. To determine the likelihood of minorities being placed in low-track classes, a recent study (Oakes 1990a) examined the proportion of secondary school science and mathematics classes at three ability levels (as reported by classroom teachers) and by the racial composition of the classes. The proportion of high-ability classes increased significantly as the proportion of white students increased. Two-thirds of all classes whose minority enrollments were disproportionately high compared to the schools as a whole were judged by the teacher to be "low ability," while more than half of the classes with relatively high white enrollment were considered to be "high ability." Fewer than 1 in 10 of the classes with relatively high minority enrollment were classified as high ability by teachers of these classes. Thus, classes having disproportionately large numbers of minority students were seven times more likely than low-minority classes to be identified as low ability rather than high ability (Oakes 1990a, pp. 23-25).

Gatekeeping Courses. Eighth grade algebra, ninth grade geometry, and high school calculus courses are considered "gatekeepers" because of their importance in the science and mathematics curriculum. Figure 1-16 shows the number of sections of these accelerated mathematics courses relative to the size of the student body of schools with high or low minority enrollment. In middle school, students attending predominantly white schools had far greater opportunities to take these gatekeeping courses. Among high schools that offered at least one section of calculus, racially mixed schools (10- to 90-percent white enrollment) had relatively comparable

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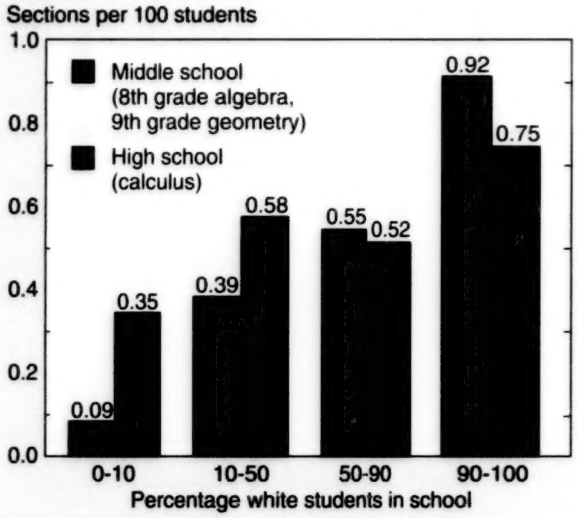
[11] Analyses cited here are based on special tabulations of data from the National Survey of Science and Mathematics Education. For detailed information on this survey, see Weiss (1987).

Figure 1-16.
Number of accelerated mathematics class sections offered, by school racial composition: 1986



SOURCE: J. Oakes, *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science* (Santa Monica, CA: The RAND Corporation, 1990).

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numbers of sections of calculus per 100 students, but high-minority schools had far fewer sections than predominantly white schools.[12]

Oakes (p. 45) summarizes the study's major findings as follows:

> To the extent that they are enrolled in secondary schools where they are the majority, low-income students, African-Americans and Hispanics have less extensive and less demanding science and mathematics programs available to them, and they have considerably fewer opportunities to take the critical gatekeeping courses that prepare them to pursue science and mathematics study after high school.

Teachers and Teaching

The quality of science and mathematics instruction that students receive is largely determined by the qualifications of their science and mathematics teachers (Shavelson, McDonnell, and Oakes 1989, p. 66). Although there is no consensus on what teacher qualifications are most important for effective teaching—or even on what constitutes good teaching—it is widely assumed that teacher competence is related to subject matter knowledge.

Past research on teacher quality indicators has been hindered by a general lack of nationally representative data bases. However, two recent large surveys of teachers and teaching conducted by the U.S. Department of Education—the Schools and Staffing Survey[13] and NELS:88[14]—permit examination of various indicators of the backgrounds and qualifications of science and mathematics teachers. More specifically, NELS:88 provided an indicator of teachers' educational background by collecting data on their coursetaking patterns. SASS reported on the match-up between (1) teachers' educational background and (2) their teaching assignments—a critical match-up from an instructional quality viewpoint.

This section focuses on these two broad topics—academic preparation and teaching assignments—to examine the issue of teacher quality in middle and high school science and mathematics classes. It also examines students' access to qualified teachers and, more broadly, the issue of teacher supply and demand.

Teacher Training

NELS:88 found a positive relationship between teacher training in mathematics and student achievement in that subject. Mathematics proficiency among the eighth grade students in the survey was set at three proficiency levels:

- *Basic*—able to perform simple arithmetic operations on whole numbers;
- *Intermediate*—able to perform simple arithmetic operations with decimals, fractions, and roots; and
- *Advanced*—able to perform problem-solving, demonstrate required conceptual understanding, and/or develop a solution strategy.

Eighth grade students whose teachers had taken an advanced course in mathematics (defined as higher than college calculus) were more likely to be at the highest proficiency level than those students whose teachers had taken courses only at the calculus level or below. However, the relationship of student achievement to teacher coursetaking in mathematics education was mixed and therefore uncertain.

Preparation: Middle School Teachers

SASS data suggest that large numbers of middle school teachers of science and mathematics could be classified as misassigned—that is, they may not be teaching courses appropriate for their training. Such misassignment can occur for any of several reasons. A school may, for instance, be too small to have a full-time chemistry or physics teacher and may assign classes in these topics to its biology teacher (Gilford and Tenenbaum 1990, p. 123). The misassignment, although understandable and frequently unavoidable, can affect the quality of instruction provided.

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[12] It should also be noted that this analysis included only high schools offering calculus, and that only about 50 percent of predominantly minority schools did so, compared with 80 percent of predominantly white schools (Oakes 1990a).

[13] SASS provides a snapshot of public and private elementary and secondary schools, principals, and other staff during the 1987/88 school year.

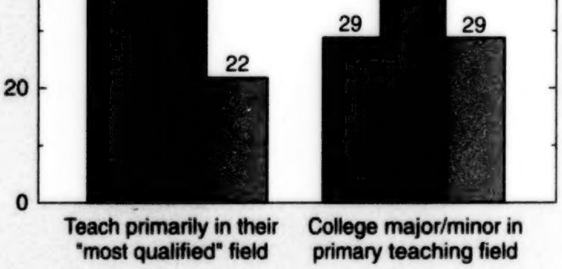
[14] A sample of the science and mathematics teachers of the NELS:88 students was included as part of the NELS:88 survey, and the college transcripts of these teachers were obtained to determine their coursetaking patterns. See footnote 10 for more information on NELS:88.

"Best Qualified" Subjects. According to SASS data, fewer than half of all middle school teachers of biological sciences and only about one-fifth of teachers of physical sciences felt they were teaching the subject for which they were best qualified. Mathematics teachers were more sure of the appropriateness of their assignments. Two-thirds of teachers of middle school mathematics felt that they were teaching the subject they were best qualified to teach. (See figure 1-17.)

College Coursework. Between 5 and 7 percent of all teachers of middle school science and mathematics had not taken any courses in the subject to which they were assigned. From 37 to 42 percent had taken 1 to 6 college courses, 27 to 35 percent had taken 7 to 12, and 22 to 26 percent had taken 13 or more college courses in the subject to which they were assigned. (See figure 1-18.)

College Majors and Minors. In the sciences, 40 percent of teachers of middle school biological sciences had majored or minored in that subject in college; another 17 percent had majored or minored in science education. Among physical science teachers (chemistry and physics), 32 percent had majored or minored in that subject in college, and 16 percent had majored or minored in science education. Only 28 percent of middle school teachers of mathematics had majored or minored in that subject in college; an equal proportion had majored or minored in mathematics education.

Figure 1-17.
Qualifications of middle school teachers of science and mathematics: 1988



SOURCE: National Center for Education Statistics, 1987/88 Schools and Staffing Survey, special tabulations by the RAND Corporation for the National Science Foundation.

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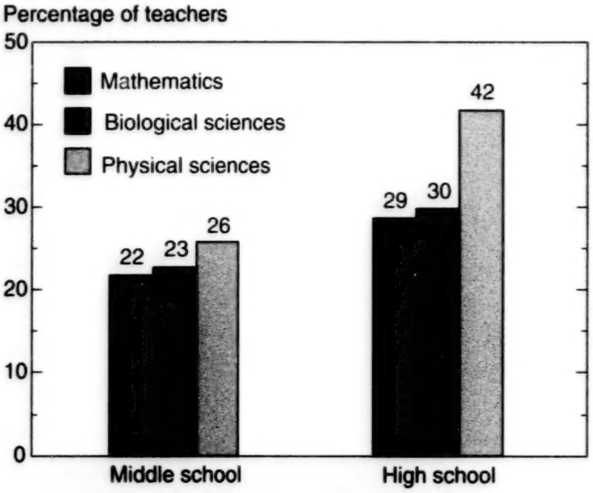
Figure 1-18.
Public school teachers who have taken 13 or more courses in their subject field: 1988



SOURCE: National Center for Education Statistics, 1987/88 Schools and Staffing Survey, special tabulations by the RAND Corporation for the National Science Foundation.

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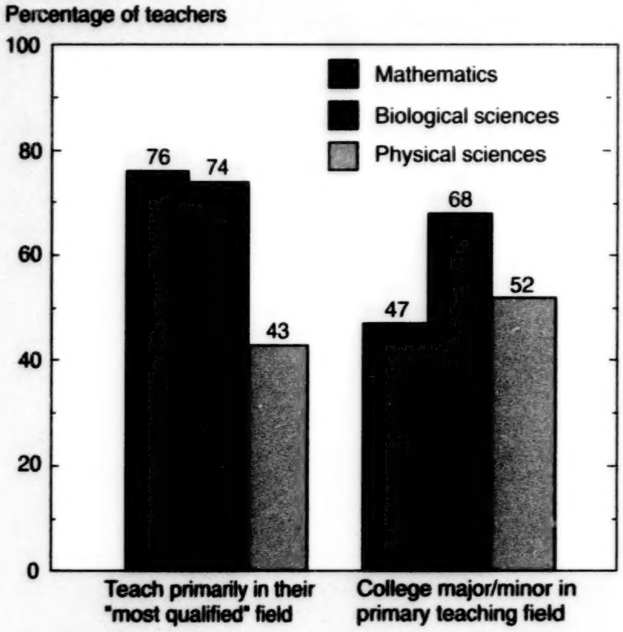
Preparation: High School Teachers

"Best Qualified" Subjects. Although teachers of high school science and mathematics appeared to have better qualifications to teach their assigned subjects than did their middle school counterparts, more than half of all teachers of physical sciences felt they were not assigned to the subject they were best qualified to teach. About one-quarter each of all teachers of biological sciences and mathematics expressed the same feeling. (See figure 1-19.)

College Coursework. Four percent of teachers of science and mathematics had not taken any college courses in the subjects to which they were currently assigned. Nearly half of the teachers of high school mathematics had taken from 7 to 12 classes in college mathematics. More than 40 percent of physical science teachers had taken 13 or more college courses in the physical sciences; about 30 percent each of teachers of biological sciences and mathematics had taken a similar number of college courses. (See figure 1-18.)

College Majors and Minors. Most high school science and mathematics teachers had pursued a college major or minor in the subject they taught. In mathematics, however, the proportion of teachers majoring/minoring in mathematics education was larger than the corresponding

Figure 1-19.
Qualifications of high school teachers of science and mathematics: 1988



SOURCE: National Center for Education Statistics, 1987/88 Schools and Staffing Survey, special tabulations by the RAND Corporation for the National Science Foundation.

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proportions of science teachers (28 percent for mathematics education compared with 17 and 16 percent, respectively, for biological sciences education and physical sciences education). Also, more than one-third of all high school teachers of physical sciences lacked a college degree in either the physical sciences or in physical science education. This finding is consistent with that of another study of secondary school teachers of physics (Neuschatz and Covalt 1988). In the second study, approximately one-third of all physics teachers were described as having their primary specialty in physics. Another third had begun their career in a different field but had taught physics regularly over the subsequent years; the remaining third were only occasional teachers of physics.

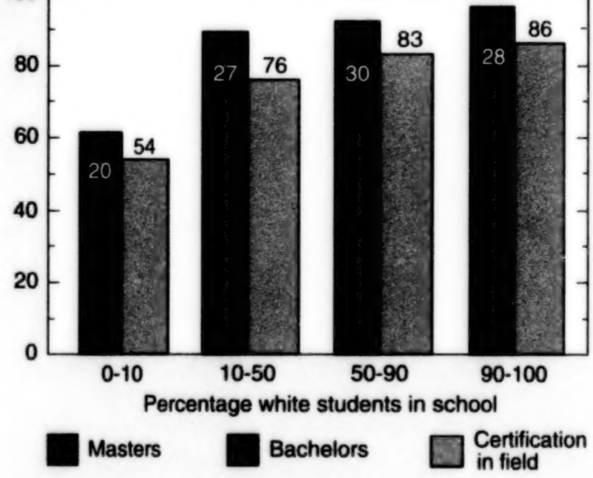
Access to Qualified Teachers

Based on several measures of teacher qualifications (e.g., certification in science and mathematics and bachelors or masters degrees in these fields), it is clear that low-income and minority students have less access than other students to the best qualified science and mathematics teachers. As shown in figure 1-20, secondary schools with high proportions of economically disadvantaged and minority students employ teachers who, on the average, were less frequently certified to teach science and mathematics and were less likely to hold bachelors or masters degrees in these subjects. Moreover, these teachers were less likely to feel well-qualified to teach these subjects.

The qualifications of teachers of various track levels at low SES, high-minority, inner-city schools differed substantially from those of teachers at high-wealth, predominantly white, suburban schools. (See text table 1-5.) For example, only 39 percent of the teachers who taught low-ability classes in low SES, minority, inner-city schools were certified to teach science and mathematics at the secondary level, compared with 84 percent of the teachers at high-wealth, predominantly white, suburban schools. One of the most notable differences was that low-track students in the most advantaged schools (high SES, white, suburban) were likely to have better qualified teachers of science and mathematics than high-track students in the least advantaged schools (low SES, high minority, inner city) (Oakes 1990a).

Eighty-four percent of public school students in the NELS:88 study had science teachers who felt well to very well-prepared to teach science.[15] But low SES students in middle schools were twice as likely as high SES students to have science teachers who felt only adequately prepared to teach science (16 versus 8 percent). Students in high-poverty schools (those in which more

Figure 1-20.
Degrees and certification of science and mathematics secondary school teachers, by school racial composition: 1987



SOURCE: J. Oakes, *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science* (Santa Monica, CA: The RAND Corporation, 1990).

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[15] In NELS:88, the teachers were asked to report how well-prepared they felt to teach their classes. Their choices were (1) very well-prepared, (2) well-prepared, (3) only adequately prepared, or (4) somewhat prepared or unprepared.

Text table 1-5.
Qualifications of secondary school teachers in high- and low-ability classes

Teacher qualifications	Low-ability classes: Low SES, minority, urban	Low-ability classes: High SES, white, suburban	High-ability classes: Low SES, minority, urban	High-ability classes: High SES, white, suburban
	Percentage of teachers			
Certified in science/mathematics	39	82	73	84
Bachelors in science/mathematics	38	68	46	78
Masters in science/mathematics	8	32	10	48

SOURCE: J. Oakes, *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science* (Santa Monica, CA: The RAND Corporation, 1990).

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than 50 percent of students received free lunches) were seven times as likely as those in low-poverty schools (those with no free lunch programs) to have science teachers who reported they felt only adequately prepared to teach science.

Teacher Supply and Demand

Recently, there has been increasing concern about shortages of qualified individuals to teach science and mathematics at the elementary and secondary school levels. The factors influencing teacher supply and demand include

- Changes in student enrollment;
- Changes in schooling policies and practices, e.g., increased graduation requirements; and
- The number of vacancies resulting from the creation of new positions and from teacher attrition.[16]

Changes in Student Enrollment. Because of the rising number of annual births since 1977, enrollment will increase in elementary and secondary schools in the 1990s. This "echo" of the baby boom of the 1950s will cause increases in the preprimary and 5- to 17-year-old populations over the next decade (Gerald, Horn, and Husson 1989). Its effects are already being felt. Specifically, after declining during the early 1980s, total school enrollment increased to 45.4 million in 1988. Enrollment is projected to continue to increase, reaching 49.5 million by the year 2000. Secondary school enrollment alone is expected to increase from 12.6 million in 1990 to 14.9 million by 2000.

Changes in School Policies. One study examined teacher supply and demand in relation to current reforms at the Federal, state, and local levels to improve the quality of education (Darling-Hammond 1984). The researchers concluded that these reforms will soon lead to critical shortages of qualified teachers unless (1) policies, such as those dealing with certification, that restrict the teaching profession are loosened and (2) teaching becomes an attractive career alternative for talented people. Otherwise, the researchers emphasized, schools will be forced to hire the less qualified to fill teaching vacancies; these teachers will then become the tenured workforce for the next several generations of schoolchildren.

Attrition—Aging and Retirement. Evidence from state time series data showed that relatively few teachers had been hired because of low attrition rates.[17] However, both hiring and attrition rates are expected to increase over the next 15 years as midcareer teachers become eligible to retire and as expected enrollment increases open more positions and allow for more mobility and promotion (Center for the Study of the Teaching Profession 1989).

The SASS survey found that, of the approximately 250,000 secondary science and mathematics teachers in the United States, 19 percent of science teachers and 18 percent of mathematics teachers were at least 50 years old. (See figure 1-21.) Thus, the current science and mathematics teaching force faces the potential of losing up to 45,000 teachers over this decade through retirement. The same study also disclosed a relatively low commitment on the part of many teachers—especially new teachers—to staying in the teaching profession. For example, only 39 percent of new mathematics teachers and 46 percent of new science teachers said they would remain in teaching "as long as able" or "until eligible to retire." And more than one-third of the new teachers were undecided at the time surveyed as to how long they would remain in teaching. (See text table 1-6.)

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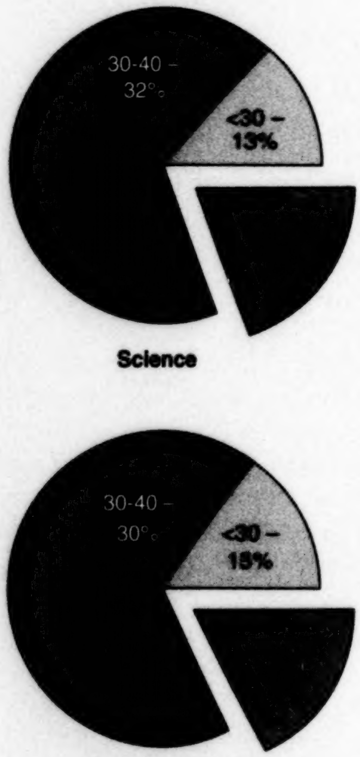
[16] Although attrition is often considered a component of demand, it is also largely a supply factor, reflecting the decisions of individual teachers about whether to stay in or leave the teaching profession.

[17] Other reasons possibly contributing to the low hiring rates include the relatively stable school-age population in recent years, lack of state and local resources, and increased pupil-teacher ratios.

Attrition—Job Satisfaction. Following up on a national sample of science and mathematics teachers from the 1985-86 National Survey of Science and Mathematics Education, Weiss and Boyd (1990) found that an average of 13,000 science and mathematics teachers left the profession annually. The annual rate of attrition for science and mathematics teachers (4.5 percent) was relatively low when compared with rates in other service professions such as nursing and social work. Nevertheless, at this rate, half of the current science and mathematics teaching corps will need to be replaced in 15 years.

The study researchers discovered that many current science and mathematics teachers were dissatisfied with various aspects of their jobs, citing adverse working conditions, student-related issues such as discipline problems, lack of adequate administrative support, low salaries and benefits, and a general lack of professional prestige. The followup study indicated that many teachers were dissatisfied with their salaries. (See figure 1-22.) Although fewer than 1 in 10 teachers named salaries as what they liked least about teaching, more than half cited higher teacher salaries as the single most important factor for teacher retention.

Figure 1-21.
Age distribution of science and mathematics secondary school teachers: 1988



SOURCE: National Center for Education Statistics, 1987/88 Schools and Staffing Survey, special tabulations by the RAND Corporation for the National Science Foundation.

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Text table 1-6.
Plans of secondary school teachers of science and mathematics to remain in teaching

Teaching plans	Science All teachers	Science New teachers	Mathematics All teachers	Mathematics New teachers
	Percent			
Total	100.0	100.0	100.0	100.0
Remain as long as able	27.4	34.3	25.7	30.4
Remain until eligible for retirement	38.8	11.2	38.7	8.3
Probably continue unless something better comes along	13.9	13.8	17.1	22.5
Definitely plan to leave as soon as can	5.0	9.6	3.5	2.2
Undecided at this time	14.8	31.2	15.0	36.7

SOURCE: National Center for Education Statistics, 1987/88 Schools and Staffing Survey, special tabulations prepared by the RAND Corporation for the National Science Foundation.

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Other recent studies indicate that salaries and the opportunity to earn higher salaries in business and industry influence the median length of time that teachers remain in the teaching profession (Murnane and Olson 1989 and 1990). Analyzing data in teacher files in North Carolina, Michigan, and Colorado, researchers concluded that, depending on the state, an annual salary differential of $2,000 might induce teachers of science and mathematics to remain in the profession from 1 to 2 years longer than generally expected. New teachers were particularly susceptible to the influence of salary on career decisions. For example, chemistry and physics teachers who command higher salaries in nonteaching occupations were almost twice as likely to leave teaching during the first year of teaching as were social science teachers.

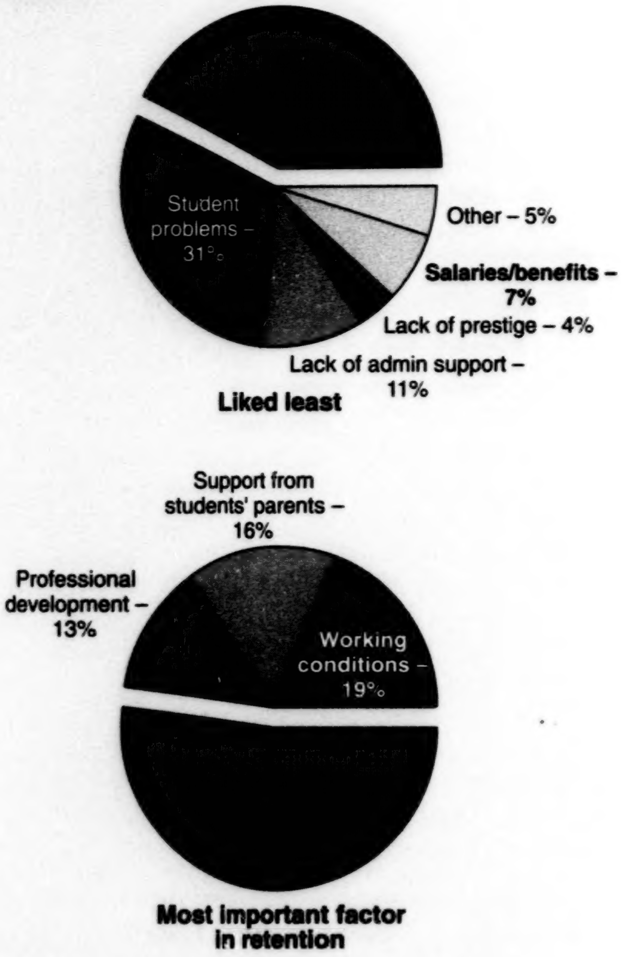
The Policy Context

National Initiatives and Reform Movements

Nationwide concern about the shortcomings of the American educational system sparked an unprecedented level of state activity during the 1980s. In almost every state, the education reform movement resulted in new legislation or state board regulations to increase standards for students; revise teacher licensure, training, and compensation practices; and/or enhance information about school performance (Fuhrman and Elmore 1990). In the wake of state-level efforts, national organizations established their own reform movements.

Figure 1-22.

Teachers' opinions about science and mathematics teaching



SOURCE: I.R. Weiss and S.E. Boyd, *Where Are They Now?: A Follow-up Study of the 1985-86 Science and Mathematics Teaching Force* (Chapel Hill, NC: Horizon Research, Inc., 1990).

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This section describes significant, ongoing national and state initiatives to improve education quality, particularly in the area of science and mathematics. It also covers the effects of state-level reform on local education entities and classroom practices and highlights a special survey of state legislators gauging their reactions to educational reforms.

The Federal Role

In 1989, the President and the 50 state governors adopted six ambitious national education goals, three of which related directly to precollege science and mathematics. (See "Students: Achievement, Interest, and Coursework, p. 16.) In addition, the President and governors provided policy guidance by developing specific objectives for each goal, with the following related specifically to precollege science and mathematics:

- The academic performance of elementary and secondary students will increase significantly in every quartile, and the distribution of minority students in each level will more closely reflect the student population as a whole.
- The percentage of students who demonstrate the ability to reason, solve problems, apply knowledge, and write and communicate effectively will increase substantially.
- Mathematics and science education will be strengthened throughout the system, especially in the early grades.
- The number of teachers with a substantive background in mathematics and science will increase by 50 percent.
- Every major American business will be involved in strengthening the connection between education and work.
- All workers will have the opportunity to acquire the knowledge and skills, from basic to highly technical, to adapt to emerging new technologies, work methods, and markets through public and private educational, vocational, technical, workplace, or other programs.

To coordinate the Federal portion of this effort, the Committee on Education and Human Resources (CEHR) was established in May 1990 under the Federal Coordinating Council for Science, Engineering, and Technology. The committee's initial challenge was to develop a systematic, comprehensive, and accurate inventory of existing Federal programs and budgets and to prepare a coordinated program budget for fiscal year (FY) 1992.

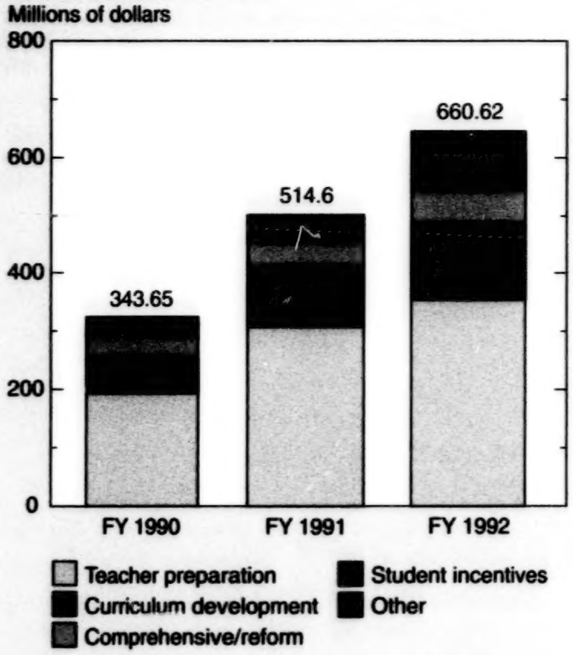
The committee established the following four budget planning priorities for the precollege level:

- Teacher preparation and enhancement;
- Curriculum and materials development, research in teaching and learning, program evaluation, dissemination, and technical assistance;
- Comprehensive programs/organization and systematic reform; and
- Student incentives and opportunities.

Throughout its planning, CEHR particularly emphasized (1) precollege education and (2) increasing the participation of groups currently underrepresented in science and mathematics fields.

Of the total FY 1992 budget request, 65 percent—\$1.94 billion—was in precollege science and mathematics. Precollege activities accounted for \$660.6 million, or 34 percent of the total (FCCSET 1991). The 1992 request represented a 28-percent increase over FY 1991 and a 92-percent increase over FY 1990. (See figure 1-23.) The Department of Education and NSF accounted for nearly

Figure 1-23.
Federal investment in precollege science and mathematics education



SOURCE: Federal Coordinating Council for Science, Engineering, and Technology, *By the Year 2000: Report of the FCCSET Committee on Education and Human Resources*, budget summary and final report, FY 1992 (Washington, DC: Office of Science and Technology Policy, 1991).

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86 percent of the FY 1992 precollege budget request. (See appendix table 1-23.)

Other National Efforts

Several national organizations independently launched parallel efforts to develop new support structures to help states and localities promote excellence in science and mathematics education. These efforts, highlighted below, include those of the National Council of Teachers of Mathematics (NCTM), the National Academy of Sciences/National Research Council, the American Association for the Advancement of Science (AAAS), and the National Science Teachers Association. These organizations adopted and released standards advocating fundamental changes in science and mathematics curriculum content, teaching approaches, and assessment techniques that place a strong emphasis on problem-solving and higher order thinking skills. These standards also maintain that all students can learn and that they deserve high-quality instruction.

National Council of Teachers of Mathematics. NCTM undertook a monumental effort to set guidelines for mathematics curriculum and assessment. The standards encourage teaching and learning that (1) rely on applications of mathematics to relevant everyday problems and situations, (2) foster students' thinking skills, and (3) push them to use their minds to solve problems in unfamiliar and new settings and to discover alternative solutions. These standards also emphasize the use of calculators, computers, and other tools to relieve the tedium of hand calculations, provide a basis for more complex problem-solving situations, and engage students in mathematics learning. The standards advocate integrating teaching with assessment and evaluating what students know and how they think about mathematics (NCTM 1989 and 1990).

National Research Council. NRC (1989) advocated a revitalization of school mathematics and emphasized how crucial it is for science, technology, and the economy that *all* students receive high-quality education in mathematics. Also under NRC auspices, the Mathematical Sciences Education Board (MSEB) prepared two reports on concepts and principles of mathematics. One, a statement of philosophy and curricular frameworks, provided a general structure to guide curriculum development for the future (MSEB 1990b). The other, on major strands of mathematical thought, was intended to stimulate creative development of new curricula that embody a broad interpretation of mathematics (MSEB 1990a). These actions, involving many different groups—mathematicians, scientists, educators, and administrators—were intended to form the basis of a national consensus for new directions in mathematics education.

American Association for the Advancement of Science. AAAS (1989) emphasized the benefits of hands-on science experimentation and recommended that students engage more actively in "collecting, sorting, cataloging; observing, note-taking, and sketching; interviewing, polling, and surveying; and using hand lenses, microscopes, thermometers, cameras, and other common instruments" (p. 147).

Other Efforts. Besides advocating significant changes in curriculum content, national organizations sought ways to help promote the changes recommended. For example, in a joint effort between AAAS and school districts, teams of teachers and researchers at six sites across the country designed curriculum and school structures for achieving the goals set forth in AAAS (1989) (see Rothman 1990, pp. 1, 21).

One current national science reform project is the Scope, Sequence, and Coordination (SS&C) project coordinated by the National Science Teachers Association. SS&C is an effort to undo the "layer cake" approach to science in which science classes are offered in discipline-specific classes (e.g., biology, chemistry, and physics) which are taken by progressively fewer students as they move into higher grades. SS&C aims to make science more attractive to students and encourage more students—especially minorities and females—to pursue

S&E careers. University educators and school teachers are working together to redesign science programs for schools in five pilot sites. Changes taking place include increased integration and coordination of the science disciplines, science instruction that progresses from the mostly empirical in the middle school grades to the increasingly theoretical and abstract in higher grades, and science courses covering fewer topics to provide students with more indepth coverage.

State Reform Movements

To date, numerous education reforms have been enacted in every state. These reform efforts vary greatly in range and scope, but most of them basically address the need to improve academic standards and upgrade teacher quality.

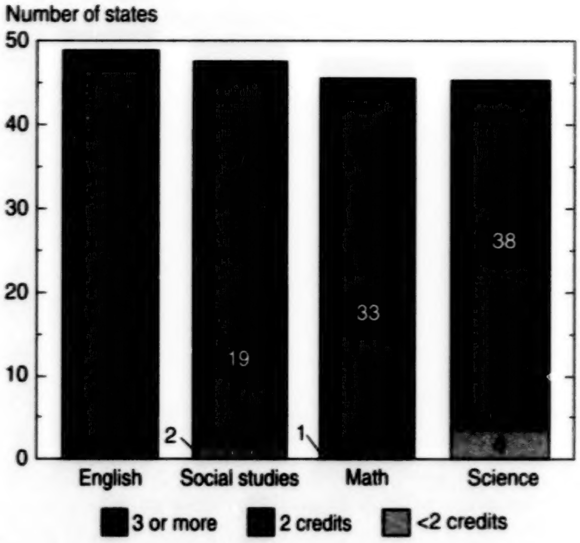
Improving Academic Standards. In 1983, the National Commission on Excellence in Education recommended that high school students take a minimum of 4 years of English and 3 years each of mathematics, science, and social studies in order to graduate. By 1990, 4 states and territories required 3 years of science, and 12 required 3 in mathematics. (See figure 1-24.) States continued to upgrade their science and mathematics requirements. For example, from 1989 to 1990, one state increased its graduation requirements to 3 years of science, and two increased theirs to 3 years of mathematics.

Some local districts require more credits in these subjects for graduation than their states do, and many students are taking more science and mathematics credits than their states require. A study by the Center for Policy Research in Education (CPRE) found that some districts had raised their requirements more than they otherwise would have in order to continue to exceed the state's minimum (Fuhrman 1991).

The CPRE study also found that science gained the most in terms of coursetaking and requirements during the 1980s. New science requirements were high relative to pre-existing coursetaking, and science coursetaking showed the largest and most consistent gains. Growth occurred primarily in beginning academic courses like physical sciences and earth sciences. In mathematics, fewer students took remedial courses such as basic mathematics and general mathematics, and more students took courses such as pre-algebra and algebra.

Another study of state policies and coursetaking in science and mathematics found that states that required 2.5 to 3 science credits had a median of 9 percent more students enrolled in science than states requiring 2 credits or less. The high-requirement states had a median of 4 percent more students taking upper-level science courses, e.g., chemistry, physics, and advanced biology. There was some evidence that a science graduation requirement above 2 credits was related to more upper-level science coursetaking, but the data were not conclusive because of the small number of states with higher science requirements.

Figure 1-24.
Number of course credits required by states for high school graduation: 1990



NOTE: Not all states reported for each field.

SOURCE: R.K. Blank and M. Dalkilic, *State Indicators of Science and Mathematics Education: 1990* (Washington, DC: Council of Chief State School Officers, 1991).

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In mathematics, the same study showed that states requiring from 2.5 to 3 credits for graduation had a median of 10 percent more students taking mathematics courses than states requiring 2 credits or less. However, the high-requirement states had a median of only 2 percent more students taking upper-level courses, i.e., geometry through calculus. These results indicated that, on average, higher state graduation requirements did not necessarily lead to substantially more students taking upper-level mathematics courses, although there were a few individual state exceptions to this pattern (Blank and Dalkilic 1991, p. 1).

Upgrading Teacher Quality. In a study of state policy issues pertaining to teachers and teaching, Fuhrman (1991) reached three conclusions concerning teacher shortages:

- The national problem was not as severe as predicted in the early 1980s,
- Shortages varied markedly by state, and
- Answers to questions about supply and demand of science and mathematics teachers varied with the criterion of teacher quality used.

Many states devised policies to increase the supply of teachers in science and mathematics. States increased the pay scale of teachers to retain and attract teachers and provided loans for students entering training in shortage fields. States also raised requirements for teacher certification in science and mathematics at

Attitudes of State Legislators Toward Science and Mathematics Education Improvements

Although there have been many studies on the attitudes toward education reform of various educational leadership groups, little is known about the corresponding attitudes and policy preferences of state legislators. To answer this need, an annual sample survey of state legislators was launched in 1990 (Miller 1990).

Are New Programs Needed? As part of the study, the legislators were asked if their states should initiate any new programs to improve science and mathematics education. Most of the legislators (80 percent) thought that some new programs were needed; however, one in five was not sure what those programs ought to be.

Among those who could identify specific programs for improving science and mathematics education, there was little consensus as to what should be done. A slim majority advocated solutions related to *program delivery,* including increased emphasis on the subjects in the classroom, longer school days, and longer school years. The second most popular set of recommendations involved *new curricula and materials.* Legislators' next-cited program preference focused on improved teacher training and increased teacher pay to yield *better qualified teachers.* The two least-cited program options were increasing state standards or requirements and establishing science and mathematics academies and magnet schools.

Is Education Sufficiently Funded? When asked about state financial support, 56 percent of the legislators indicated that too little was being spent on public elementary and secondary education in their states. In fact, legislators placed elementary and secondary education near the top of their list of underfunded state programs. Only a third of those surveyed indicated that their states' educational funding was adequate; another 8 percent thought that their states were providing too much support to public education.

Although there was no consensus as to what areas of education should receive the highest funding priority, 16 percent of the legislators supported *improved teacher programs.* Another 13 percent cited a need for *preschool and elementary school programs.*

Interestingly, hardly any of the legislators identified improvements in science and mathematics education as the primary target of additional state spending. Given legislators' general recognition of problems in science and mathematics education, this finding could indicate that most state legislators viewed these problems as only one aspect of a broader set of educational reform issues to be addressed.

elementary and secondary levels. Some states passed alternative certification policies intended to attract noncertified college graduates to teaching, and many states instituted mandatory teacher assessments to ensure that new teachers (and, in two states, *all* teachers) met standards for verbal ability, knowledge of their teaching field, and knowledge of education in general (Blank and Dalkilic 1991, p. 26).

The age distribution of science and mathematics teachers indicated little likelihood nationwide of greater shortages of teachers in these subjects than in other subjects. The fields of chemistry and physics had slightly more teachers older than age 50 than other teaching fields, but all the science and mathematics fields had teachers younger than the average for all high school teachers. A shortage of science and mathematics teachers could be anticipated in a few states with much higher percentages of their teaching force older than age 50 than other states.

In some states, the majority of science and mathematics teachers majored in college in the subject they teach. But other states had relatively few teachers with majors in their subject. About half of all high school science and mathematics teachers had a college major in their assigned field. In most states, school districts were able to hire and assign state-certified science and mathematics teachers, but many of these teachers did not meet higher standards for preparation such as having a college major in their assigned field or meeting standards set by professional societies (Blank and Dalkilic 1991, p. 42).

Impacts of State Reforms: Case Studies

Several assessments of state-level reforms have been undertaken by individual states, the Center for Policy Research in Education, and the Center for the Learning and Teaching of Elementary Subjects in conjunction with the National Center for Research on Teacher Education. In general, these assessments attempt to address some or all of the following issues:

- Were the policies successful?
- What were the effects of the reforms?
- How were reforms implemented at the local level?
- How have policies affected teachers' choices about teaching practices and course content?

Success of Policies. Some state reforms that were initially seen as unlikely to be implemented by local school districts may be yielding more benefits than anticipated. For example, both California and South Carolina have been systematically tracking the effects of their education reform packages for 4 years. Both sets of assessments reveal that, although there is substantial room for improvement, many of the initiatives have been successfully implemented, have led to important changes in districts and schools, have raised targeted indicators of student performance, and have not—as many observers anticipated—left at-risk students behind (Murphy 1989, pp. 217-18).

Effects of Reforms. In a study of educational reform in six states (Arizona, California, Florida, Georgia, Minnesota, and Pennsylvania) undertaken by CPRE, investigators concluded that educational reforms to increase high school graduation requirements exerted a powerful influence over schooling (Fuhrman and Elmore 1990, p. 86). Among other effects, these reforms led to different course offerings by many districts and schools, new coursetaking patterns by large numbers of students, more attention to the knowledge and skills addressed by standardized tests, and adjustments in teacher assignments. These changes were effected even though many districts had already met or exceeded the new requirements.

The study found that many local districts enacted policies of their own that exceeded the state mandates. As a result, low-achieving students were more affected than others by changes in minimum graduation requirements, because higher achieving students were already likely to be taking courses imposed by new state standards (CPRE 1990, p. 4). This local activity took a variety of forms, e.g., enacting policies in anticipation of high state mandates and using the state policies to achieve their own district objectives. For example, of the 24 districts studied in the 6 states, 10 had a strong form of curriculum frameworks, course syllabi, tests, textbooks, and (in some cases) teacher evaluation instruments to produce a more uniform curriculum across district schools.

Implementation of Reforms. According to the findings of the CPRE study, states that had significant effects on local education agencies appeared to rely more on multiple mechanisms of influence than on direct control. The following are examples of successfully used mechanisms of influence.

- *Mobilization of professional and public opinion*—the school reform packages of at least four states in the CPRE sample were heavily influenced by organized business interests, which mobilized public opinion around highly visible statements of the rationale for education reforms.

- *Using information about performance to shape the local school district policy environment*—California and Florida published the results of state performance assessments, using their extensive information on school-level performance to shape the terms of debate about the success of educational reform and school effectiveness.

Effects on Teachers' Choices. The CPRE study also found that new state and district policies appeared to have affected teaching practices less than course content. States and districts had revised curriculum guides and frameworks in an effort to lend greater emphasis to higher order thinking skills and problem-solving. But the study evidence suggested that state and district activity in this area affected teachers only sporadically. Some teachers adopted new practices, while others continued to use the same pedagogy and emphasize similar kinds of knowledge as before.

Problems associated with the implementation of policies to increase higher order skill teaching included the fact that only limited resources were devoted to staff development in this area. Also, laboratory work continued to play a relatively small role in most science classes because many schools had inadequate laboratory facilities and lacked chemicals and equipment necessary to conduct basic laboratory exercises.

Another study focused on changes in elementary school mathematics classroom teaching practices as they related to a newly enacted California state policy of teaching mathematics for understanding.[18] The policy reflected an effort to shift mathematics teaching from mechanical drill and memorization toward reasoning and understanding. Unlike many similar policies that either set broad goals or required that certain courses be taken, the California reform used the concept of instructional "alignment" to improve mathematics teaching and learning. In accordance with this concept, the state recast its curriculum guidelines, textbooks, and assessments to convey clear messages of change to both teachers and students.

The policy challenged basic beliefs about mathematics, about how students learn mathematics, and about how teachers perceive their role and conduct their classes. Based on preliminary analyses, teacher responses to the new policy appear to vary widely. Several of the teachers viewed mathematics rather traditionally, as a sequence of topics to be covered serially. These teachers organized the new content into the existing structure of traditional school mathematics. Some teachers saw the policy as a new source of teaching strategies and fully exploited the policy's recommendation to transmit material more effectively through such tactics as classroom games, filmstrips, and concrete models. Other teachers used these strategies too; however, these individuals used the strategies as simply a novel means of capturing students' attention in memorizing the traditional rules and procedures without giving students an opportunity to explore on their own. Consequently, these teachers, like the first group described, filtered the new mathematics instruction policy through the traditional structure of rote learning.

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[18] This study included nine teachers in six different elementary schools (half of which were high SES schools and half of which were low) in three different California school districts (Cohen 1990).

Summary

Following an outpouring of Federal, state, and local educational reform, overall student achievement in science and mathematics since 1977 is beginning to improve—but the levels are only at those attained around 1970. There are positive results in terms of equality of educational attainment: gaps in performance in science and mathematics between black and Hispanic students and their white peers are being reduced. Attainment in analytical and higher order skills remains low and substantially unchanged.

Why there has not been more progress is a matter of continuing national debate. One significant finding in this regard is that inadequate resources for staff development and for laboratory equipment have inhibited effective implementation of state and district policies to increase school teaching of higher order thinking and analytical skills.

Numerous national and international studies point to a number of aggregated and individual variables (most of which have been reported in this chapter) that appear to be positively related to educational success. But no matter how detailed and careful the statistical analysis, causal relationships cannot be inferred based on these data alone—whether students with higher proficiency seek out more rigorous courses in school and pursue them with more rigid academic vigor, or whether the courses themselves strengthen proficiency.

Applebee, Langer, and Mullis (1989, p. 6) draw the following conclusion about the current status and condition of education in the United States:

> American education is at a crossroads. While academic achievement appears to be improving after years of decline, the continuing lack of growth in higher-level skills suggests that more fundamental changes in curriculum and instruction may be needed in order to produce more substantial improvements. The educational system in this country needs to extend its focus from the teaching and learning of skills and content to include an emphasis on the purposeful use of skill and knowledge.

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Chapter 2
Higher Education in Science and Engineering

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Higher Education in Science and Engineering

HIGHLIGHTS

Characteristics of Higher Education Institutions

- **Research I universities dominate science and engineering (S&E) doctorate production; they also award a sizable proportion of S&E baccalaureates.** In 1988, research I universities, which accounted for about one-quarter of the U.S. academic institutions that offered S&E doctorate study, awarded two-thirds of the year's S&E doctorates. The 5 percent of baccalaureate-granting schools classified as research I produced 30 percent of S&E bachelors degrees. *See pp. 46-47.*

- **Tracing the baccalaureate institutional origins of recent S&E doctorate recipients reinforces the significant role played by research-intensive universities.** About two-fifths of the people who earned S&E doctorates between 1985 and 1990 had received their bachelors degrees at research-intensive universities. Another one-quarter received their baccalaureates from other doctorate-granting institutions. *See pp. 47-48.*

- **Comprehensive I schools are more significant in baccalaureate and masters S&E education than in doctoral studies.** Roughly 29 percent of S&E bachelors degrees and 21 percent of masters degrees were granted by comprehensive I schools in 1988. In contrast, these schools accounted for about 1 percent of S&E doctorates. *See pp. 46-47.*

Undergraduate Students

- **In the late eighties, female undergraduates outnumbered males, and the proportion of undergraduates in their late 20s or older continued to grow.** Despite declining enrollments by the traditional college-age group (18- to 21-year-olds) in the eighties, undergraduate enrollments increased by almost 2 million. Some of this increase was due to greater participation in higher education by females, particularly older females. In 1988, females represented over half of both undergraduate enrollment and high school graduates. *See p. 48.*

- **Increasingly, undergraduates have been enrolling part time and attending 2-year institutions.** Part-time students made up over 40 percent of undergraduate enrollment in 1988; this proportion was up from 25 percent 10 years earlier. Enrollments in 2-year colleges have also risen significantly, accounting for more than half the growth in overall undergraduate enrollments in the last 10 years. *See p. 48.*

Freshman Characteristics

- **Among freshmen intending to major in S&E fields, the proportion choosing natural science steadily declined in the last 20 years; concurrently, interest in engineering, which had faltered, began to recover.** The percentages of S&E freshmen who planned a major in mathematics or the physical sciences declined between 1971 and 1990. Interest in engineering, on the other hand, continued to increase until the early eighties at which point it declined; the latter part of the eighties saw a slow increase in freshman interest. *See p. 49.*

- **Underrepresented minorities are less likely than whites and Asians to plan a major in S&E fields.** In 1990, roughly one-third of blacks, Native Americans, and Hispanics reported an S&E field as their probable major. In contrast, over two-fifths of Asians planned to major in science or engineering. *See p. 49.*

S&E Degree Production and Graduate Enrollments

- **Undergraduate degree production declined during the 1980s in most S&E fields.** Over the decade, the number of degrees dropped in most natural and behavioral science fields but rose in the computer sciences. Between 1985 and 1989, the number of undergraduate degrees awarded dropped in virtually all S&E fields except the behavioral sciences. *See p. 50.*

- **Some leading indicators suggest that the decline in the proportion of bachelors degrees awarded in S&E fields may level off in the near future.** Data on freshman plans predict that the long-term decline in the proportion of natural science degrees may have bottomed out in 1990 and that recovery may be evident in the proportions of computer science and engineering degrees in 1992. Bachelors degrees in the behavioral sciences are likely to peak as a percentage of all baccalaureates in the early nineties. *See p. 52.*

Financial Support

- **Financial support for graduate education has shifted somewhat toward non-Federal sources.** Non-Federal sources of financial support were reported by a majority (53 percent) of S&E graduate students in 1990, up from 48 percent 10 years earlier. During the same period, Federal sources, which had declined in the early eighties, began to rebound in the latter half of the decade. *See p. 57.*

Foreign Participation in S&E Graduate Education

- **Participation by foreign citizens in U.S. S&E graduate programs has increased.** S&E graduate enrollment of foreign citizens increased by more than two-fifths during the eighties; in 1990, foreigners accounted for more than one-quarter of the graduate students in these fields. Similarly, among S&E doctorate recipients, foreign participation almost doubled over the decade. In 1990, about one in three S&E doctorate recipients was on either a temporary or permanent visa. *See pp. 58-59.*

- **Foreign citizens tend to concentrate on engineering and certain natural science fields rather than on the behavioral sciences.** In 1990, the majority of doctorates in engineering (57 percent) and mathematics (56 percent) were granted to non-U.S. citizens. In comparison, foreign students received 36 percent of the doctorates granted in the social sciences and only 6 percent of those in psychology. *See p. 59.*

International Comparisons of Baccalaureate Production

- **There has been a rapid rise in bachelors degree production in natural science and engineering (NS&E) fields in Asia.** Between 1975 and 1988, NS&E degrees more than doubled in South Korea, Singapore, and Taiwan. The comparable increase in developed countries was 16 percent. *See p. 60.*

- **Participation in NS&E education is highest in the USSR.** About 9 percent of 22-year-olds in the USSR earned baccalaureates in NS&E fields in 1988, compared to 5 percent in the United States and 0.6 percent in China. *See pp. 61-62.*

Introduction

Chapter Focus

This chapter focuses on higher education in science and engineering (S&E). Specifically, indicators are examined for the following three topic areas:

- *Characteristics of U.S. institutions that grant degrees in S&E.* Exploring the characteristics of the different types of institutions that grant S&E degrees reveals the very different roles that these institutions play in the educational process. Classifying universities and colleges by broad categories shows differences by both degree level and discipline.

- *Characteristics of the U.S. student population at the undergraduate and graduate levels.* Trends in degree production and enrollments among the U.S. student population indicate two phenomena. At all educational levels, increasing percentages of the postsecondary population are made up of women and older students. Partially reflecting these demographic trends, there has been a marked decline in the choice of many S&E fields as areas of study, especially at the baccalaureate level.

- *International issues.* S&E education is becoming increasingly internationalized. For example, the number of foreign students studying at U.S. institutions, particularly at advanced degree levels, has grown so much more rapidly than that of U.S. students that foreign students now account for more than half of the doctorates awarded in some S&E fields. Another international issue involves the comparison of the number of S&E degrees awarded by various countries. For example, in Japan, about 6.4 percent of the college-age population received first university degrees in the natural sciences and engineering. In the United States, this proportion was 5 percent.

Chapter Organization

This chapter is divided into five major sections. The first of these provides information on indicators related to the characteristics of U.S. institutions including (1)the different types of institutions that award S&E degrees at various levels and (2)baccalaureate origin institutions of recent S&E doctorate recipients.

The second and third sections cover topics related to the characteristics of American college freshmen and high school graduates; graduate enrollment in S&E programs; and S&E degree production at the baccalaureate, masters, and doctorate degree levels. The fourth section explores a related indicator, that of major sources of financial support reported by undergraduate and graduate students in U.S. institutions.

The final section of the chapter revolves around two issues of international comparison: (1) the increasing number of foreign students at U.S. colleges and universities and (2) degree production trends for selected countries, including six Asian countries.

Characteristics of Higher Education Institutions

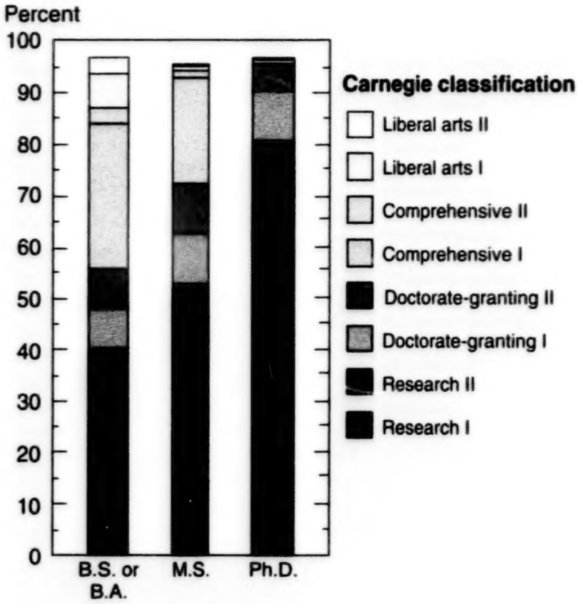
There are more than 3,000 institutions of higher education in the United States, playing a variety of roles at each degree level in the S&E education process. To assess and examine the different characteristics of these institutions, a classification scheme was developed by the Carnegie Foundation for the Advancement of Teaching (Carnegie 1987). Widely used by the academic community as a means of viewing the overall structure of the U.S. higher education system, the classification system was first introduced in 1970 and revised slightly in 1976 and 1987. See "Classification of Academic Institutions," p. 47, for a brief description of the Carnegie categories used in this chapter.

Bachelors Level

Of the 1,700 institutions that granted baccalaureates, almost 1,400 granted degrees in S&E fields in 1988. (See text table 2-1.) Comprehensive I and liberal arts II schools accounted for over half of the institutions with S&E programs; research I and research II universities represented 5 and 2 percent, respectively, of all institutions offering S&E baccalaureates. These proportions change, however, by S&E field. For example, almost 17 percent of the schools offering undergraduate engineering degrees were in the research I category, while these schools represented 5 percent of undergraduate degrees in the natural sciences.

Research I and comprehensive I schools accounted for the largest fractions of S&E baccalaureates awarded: 30 percent and 29 percent in 1988. (See figure 2-1.) Liberal arts II schools, on the other hand, granted fewer than 4 percent of all S&E baccalaureates that year. Again, differences emerge by discipline. About two-fifths of all engineering graduates were from research I schools, and about one-third of natural science graduates attended comprehensive I institutions.

Figure 2-1.
Relative production of science and engineering degrees, by degree level and institution type: 1988



See appendix tables 2-1, 2-2, and 2-3.

Science & Engineering Indicators – 1991

Text table 2-1.
Number of academic institutions with science and engineering (S&E) programs, by degree level: 1988

Type of institution	S&E bachelors programs	S&E masters programs	S&E doctorate programs
Total	1,392	645	291
Research I	67	68	70
Research II	34	34	34
Doctorate-granting I	47	48	48
Doctorate-granting II	54	57	52
Comprehensive	394	275	35
Comprehensive II	163	43	2
Liberal arts I	138	28	3
Liberal arts II	380	26	1
Two-year institutions	15	0	0
Specialized	83	45	33
Other	11	19	13
Not classified	6	2	0

See appendix tables 2-1, 2-2, and 2-3.

Science & Engineering Indicators – 1991

In terms of *percentage* of bachelors degrees awarded in science and engineering (i.e., S&E productivity), other types of institutions stood out. For example, almost 45 percent of the degrees awarded by liberal arts I schools were in S&E fields in 1988. Also, a third of the degrees in research II and doctorate-granting II schools were in these fields. In comparison, S&E degrees represented 25 and 20 percent, respectively, of the degrees awarded by comprehensive I and liberal arts II institutions. About 43 percent of the degrees conferred by research I schools were in science and engineering.

Historically black colleges and universities are vital to the undergraduate education of minorities in science and engineering. These schools comprise fewer than one-tenth of the number of institutions in the three Carnegie categories in which they are classified (comprehensive I and II and liberal arts II). Yet, historically black colleges and universities account for about one-third of natural science and engineering (NS&E) baccalaureates earned by minorities who are underrepresented in S&E (i.e., blacks, Native Americans, and Hispanics). In the aggregate, comprehensive I and II and liberal arts II schools graduate about 62 percent of minorities earning NS&E degrees.

Masters Level

About 65,000 S&E masters degrees were awarded by 645 institutions in 1988. Comprehensive I schools made up the largest proportion of these masters-granting schools (43 percent); the next largest proportion (11 percent) was the research I category.

Classification of Academic Institutions

Following are brief descriptions of the Carnegie categories used in this chapter (Carnegie 1987).

Research I: institutions that offer a full range of baccalaureate programs, are committed to graduate education through the doctorate degree, and give high priority to research. They receive at least $33.5 million annually in Federal support and award at least 50 Ph.D. degrees each year.

Research II: institutions that offer a full range of baccalaureate programs, are committed to graduate education through the doctorate degree, and give high priority to research. They receive between $12.5 and $33.5 million annually in Federal support and award at least 50 Ph.D. degrees each year.

Doctorate-granting I: in addition to offering a full range of baccalaureate programs, the mission of these institutions includes a commitment to graduate education through the doctorate degree. They award at least 40 Ph.D. degrees annually in five or more academic disciplines.

Doctorate-granting II: in addition to offering a full range of baccalaureate programs, the mission of these institutions includes a commitment to graduate education through the doctorate degree. They award at least 20 or more Ph.D. degrees annually in at least one discipline or 10 or more Ph.D. degrees in three or more disciplines.

Comprehensive I: institutions that offer baccalaureate programs and, with few exceptions, graduate education through the masters degree. More than half of their baccalaureate degrees are awarded in two or more occupational or professional disciplines such as engineering or business administration. All of the institutions in this group enroll at least 2,500 students.

Comprehensive II: institutions that award more than half of their baccalaureate degrees in two or more occupational or professional disciplines, such as engineering or business administration, and may also offer graduate education through the masters degree. All of the institutions in this group enroll between 1,500 and 2,500 students.

Liberal arts I: highly selective institutions that are primarily undergraduate colleges that award more than half of their baccalaureate degrees in arts and science fields.

Liberal arts II: primarily undergraduate colleges that are less selective and award more than half their degrees in liberal arts fields. This category includes a group of colleges that award fewer than half their degrees in liberal arts fields but, with fewer than 1,500 students, are too small to be considered comprehensive.

Two-year community, junior, and technical colleges: institutions that offer certificate or degree programs through the associate degree level and, with few exceptions, offer no baccalaureate degrees.

Professional schools and other specialized institutions: institutions that offer degrees ranging from the bachelors to the doctorate. At least half of the degrees awarded by these institutions are in a single specialized field. These institutions include theological seminaries, bible colleges, and other institutions offering degrees in religion; medical schools and centers; other separate health profession schools; law schools; engineering and technology schools; business and management schools; schools of art, music, and design; teachers colleges; and corporate-sponsored institutions.

S&E masters degree production is most highly concentrated in research I schools. Over two-fifths of the degrees awarded in 1988 were made by this type of school. By broad field, over half of engineering degrees and two-fifths of natural science degrees were from research I schools. In the social sciences and psychology, on the other hand, research I schools accounted for slightly more than one-quarter of degrees; comprehensive I schools accounted for another three-tenths.

Doctorate Level

The production of S&E doctoral degrees is concentrated in fewer than 300 institutions. Almost 70 percent of these schools were research or doctorate-granting institutions. The 300 doctorate-granting institutions awarded almost 21,000 S&E degrees in 1988.

Regardless of S&E field, research I schools produce the majority of S&E Ph.D. recipients. In 1988, more than two-thirds of natural science doctorates and almost three-quarters of engineering doctorates were conferred by research I institutions. Similarly, these schools accounted for over half of all social science and psychology doctorates awarded.

Baccalaureate Institutions Attended by S&E Doctorate Recipients[1]

Recent S&E doctorate recipients cited approximately 1,400 U.S. colleges and universities as the sources of their undergraduate degrees. Using the Carnegie classification to examine the types of source institutions indicates that these are concentrated in two major categories. These categories—research and doctorate-granting institutions—accounted for about two-thirds of the baccalaureate degrees awarded to new doctorate recipients; interestingly, together they represented only about 15 percent of the 1,400 schools.

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[1] This section explores the baccalaureate origin institutions for doctorate-holders who received their S&E Ph.D. degrees in academic years 1985-90. Cohorts were combined to ensure an adequate number of cases for analysis. Data in this section are from SRS (forthcoming [c]).

Type of institution varied somewhat by field. For example, roughly half of the individuals who held Ph.D. degrees in either the computer sciences, agricultural science, or engineering received their bachelors degrees at a research university. Among psychology and social science Ph.D. recipients, on the other hand, about one-third earned baccalaureates from these schools.

Although research and other doctorate-granting schools are the primary S&E baccalaureate origin institutions of recent S&E Ph.D. recipients, non-doctorate-granting institutions are also significant. For example, about one-fifth of new Ph.D. recipients earned their undergraduate degrees from comprehensive institutions. These schools were especially prominent as institutional origins for Ph.D. recipients in the physical, biological, and social sciences and psychology. In addition, liberal arts colleges served as the baccalaureate origin institutions for 14 percent of new doctorate recipients.

Undergraduate S&E Student Population

Recent Trends in College Enrollments[2]

The composition of the undergraduate student body as a whole has changed markedly over the last 25 years. Increasingly over this period, higher fractions of undergraduates were

- Older,
- Female,
- Attending school part time,
- Attending 2-year institutions, and/or
- Returning to school after an interruption in their studies.

Larger fractions of these students contributed heavily to the unexpectedly high increases in undergraduate enrollment over the last decade. Many of these students, however, are less prone to earn bachelors degrees in S&E fields. Consequently, S&E degree production did not keep pace with growth in overall enrollment. Factors in this growth are described below.

In the last two decades, undergraduate enrollment grew considerably faster than did the traditional undergraduate age group (18- to 21-year-olds). Concurrent with the decline in this group was an increased demand for higher education by ***all age groups***. The percentage of 18- to 24-year-olds enrolled as undergraduates rose from about 24 percent in the late seventies to 28 percent in 1989. For 25- to 44-year-olds, the increase was proportional to that of the younger group, rising from 4.5 percent to 5.3 percent.

Women are participating in postsecondary education in much greater numbers. By 1988, they comprised a greater share of undergraduate enrollment than they did of high school graduates: 54 percent versus 51 percent. Twenty years earlier, these percentages were 42 and 51, respectively.

Part-time enrollment in undergraduate programs rose significantly between 1979 and 1989. More than two-fifths of undergraduate students were enrolled on a part-time basis, up from about one-quarter. This increase reflects three trends: (1) a rising tendency among older women to return to college after dropping out to start families and/or work full time, (2) an increase in 2-year college enrollments, and (3) an increase in students who either delay entry to college or extend the period of their studies past the traditional 4 years.

Concomitant with growth in part-time enrollments is growth in *2-year college enrollments.* More than half of the increase in undergraduate students was accounted for in 2-year institutions. In addition, the share of all undergraduates who were enrolled part time in 2-year schools rose from 11 to 27 percent. Female part-time students accounted for two-thirds of the increase. In 1989, females accounted for 16 percent of part-time students at 2-year institutions, up from 5 percent in 1967. The increase in 2-year college enrollments of women reflects many factors, including the relative affordability of 2-year institutions and the larger number of evening classes offered by these schools.

Finally, a greater number of students appear to be either *returning to school* after interrupting their studies or beginning their studies several years after graduating from high school. An indication of these trends is that the number of first-time freshmen at 4-year universities and colleges remained fairly level over the last two decades, even though overall enrollments increased dramatically.

Characteristics of American College Freshmen[3]

This section explores trends in the following selected characteristics of first-time full-time freshmen enrolled in 4-year universities and colleges over the last 20 years:

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[2] This section discusses trends in undergraduate enrollments *overall*, not just in S&E programs.

[3] Data in this section are from the Higher Education Research Institute, University of California at Los Angeles, the American Freshmen Norm Survey, unpublished tabulations. Note that although the institutional population for this survey is drawn from all "eligible" institutions of higher education (i.e., all institutions that were operating at the time of the survey and had a freshman class of at least 25 students) listed in the annual U.S. Department of Education *Education Directory*, the actual sample is self-selected. For example, of the 2,725 eligible institutions invited to participate in the 1989 survey, 599 responded. Any biases that may result from this selection process are corrected in the stratification scheme.

- High school grades,
- Parents' education and occupations,
- Planned majors,
- Planned careers, and
- Highest degree planned.

High School Grades. In the last two decades, grades reported by freshmen who intended to major in a science or engineering field leveled off after an initial increase. For example, the average percentage citing their high school grades in the "mostly A or A+" range rose from 10 percent in 1971 to 20 percent in 1978 but remained around 20 percent through 1990. The percentage of S&E students showing a B average or better has been about 80 percent since the early seventies. In comparison, over most of the last two decades, the distribution of grades reported by freshmen majoring in non-S&E fields was about 10 percent in the A range and about 70 percent in the B or better category.

Parents' Education and Occupations. Between 1971 and 1990, there was a steady increase in the education levels of S&E freshmen's parents. For example, the fraction of fathers who held bachelors degrees rose from 22 to 23 percent, while the proportion of mothers who had earned these degrees increased from 18 to 23 percent. In addition, the proportion of fathers who held graduate degrees rose from 13 percent to 24 percent; for mothers, the increase was from 4 to 13 percent.

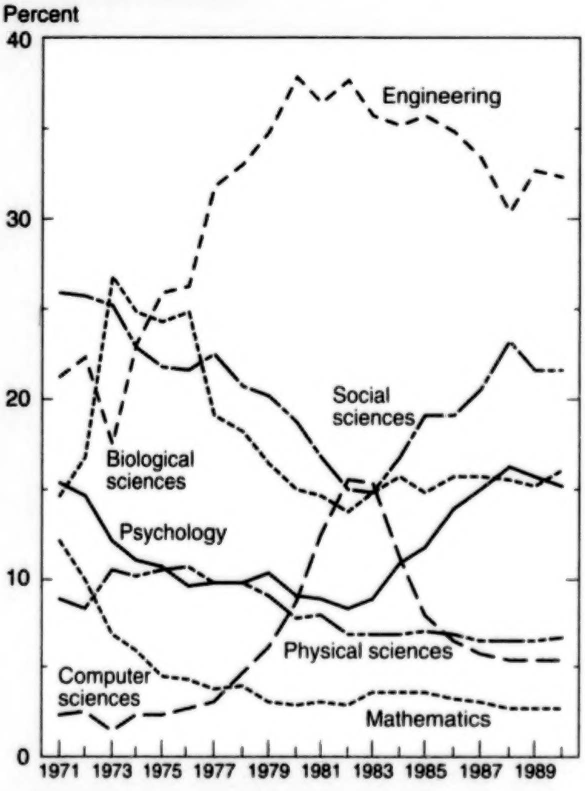
Regarding parental occupations reported by S&E freshmen, virtually no change was evident between 1971 and 1990 in the distribution of fathers' occupations. There was, however, a shift in the fraction who reported that their mothers held professional jobs. While the proportion of mothers who worked as skilled or semi-skilled operatives remained steady at 5 percent throughout this period, the proportion working as lawyers, health professionals, teachers, and clergy rose from 12 percent to 23 percent. Mothers' representation in business occupations also increased, rising from 5 to 14 percent.

Planned Majors.[4] The most notable changes in the planned S&E majors of college freshmen over the last two decades were in the fields of engineering, the computer sciences, and the social sciences. Interest in engineering as a probable major peaked in the early eighties, declined, and began to rise again at the end of the decade. Interest in the computer sciences also peaked in the early eighties but has not shown any recovery. In contrast, majors in the social sciences have increased steadily after a two-decade low in 1983. (See figure 2-2 for a more complete picture of the changes in distribution of freshmen's planned S&E majors.) Much of the rise in students planning to major in the social sciences and psychology is attributable to female freshmen. In 1990, about 55 percent of female S&E freshmen chose these fields of study, up from 39 percent in the early eighties.

Examining intended majors by racial/ethnic group reveals that members of those minorities that are underrepresented in S&E—blacks, Native Americans, and Hispanics—are less likely to choose an S&E field than are other groups. In 1990, about one-third of blacks, Native Americans, and Hispanics planned to major in an S&E field, while over two-fifths of Asian freshmen did so. By field, underrepresented minorities are more apt to choose social science or psychology fields; Asians are more inclined toward the physical sciences and engineering.

Planned Careers. In 1990, engineering was the probable career chosen by the largest fraction of freshmen planning an S&E major (28 percent). Law (10 percent) and scientific research (6 percent) were the next most frequently cited occupations. (See figure 2-3.) Since 1970, the proportions of S&E freshmen choosing these three careers have differed substantially. While the fraction choosing law practically doubled over the 20-year period, interest in scientific research careers dropped by a third. Interest in engineering careers, on the other hand, followed a pattern similar to those of freshman intentions and baccalaureate production in the field: Interest peaked in the early eighties, declined, and began to rise again in the latter part of the decade.

Figure 2-2.
Intended science and engineering majors of American freshmen



See appendix table 2-5. *Science & Engineering Indicators – 1991*

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[4] Data on agricultural sciences are not included in S&E fields for American freshmen.

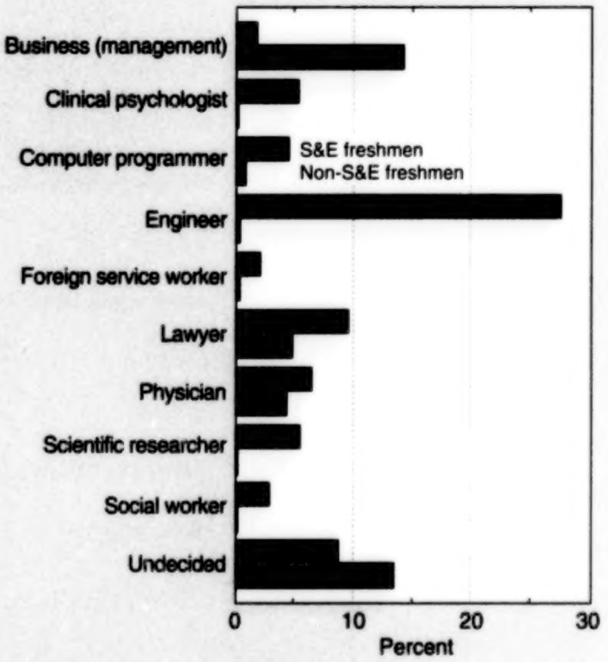
Differences in career plans emerge when examined by gender. For example, 40 percent of male freshmen chose engineering; another 6 percent planned a computer programming career. Among female freshmen, the proportions citing these career choices were about 12 and 4 percent, respectively. Females were more inclined toward careers in psychology or social work than males (18 percent versus 2 percent). Females were also more likely to be undecided about their career plans than males (11 versus 7 percent).

Highest Degree Planned. Interest in earning advanced degrees edged upward among S&E freshmen over the last two decades. For example, the fraction planning to earn a Ph.D. increased from 19 percent in the early seventies to 25 percent in 1990. In contrast, those who cited the baccalaureate as their highest degree planned fell from 31 to 19 percent. This general pattern of degree plans also existed among freshmen choosing non-S&E majors, although the largest increase for those students was in the proportion planning to earn a masters degree: 29 percent in 1971 to 42 percent in 1990.

Engineering Enrollments

In most fields, especially the sciences, students are not required to declare their majors until the second or third year. Exceptions to this general rule are engineering and engineering technologies. Undergraduate programs in these fields are often professional curricula that start in the first year. Surveys by the Engineering Manpower Commission provide trend data on full- and part-time engineering and engineering technology enrollments in both baccalaureate and 2-year programs.[5] Data on first-year enrollments in these fields provide early indicators of future degree production patterns as well as changes in student preferences toward engineering study.

Figure 2-3.
Probable careers of American freshmen in 1990



See appendix table 2-5. *Science & Engineering Indicators – 1991*

Full-time enrollments in engineering programs rose from the late seventies until the early eighties and then fell sharply. In the fall of 1989, the number of freshmen enrolled in full-time engineering programs was about 95,000, down from a high of more than 115,000 during 1981 and 1982. (See figure 2-4.) Fluctuations in part-time enrollments indicate no consistent trend over the decade.

Trends in engineering technology programs mirror those in engineering. First-year enrollments dropped after the early eighties, although these numbers apparently stabilized in the latter part of the eighties. Comparatively, part-time enrollment in technology programs has been increasing during the last several years.

S&E Baccalaureate Production[6]

S&E bachelors degree production fluctuated during the 1980s. The number of S&E bachelors degrees awarded each year increased until about 1986, fell sharply in 1987 and 1988, and leveled off in 1989. Despite these fluctuations, people earning S&E baccalaureates accounted for increasingly larger fractions of the general population, rising from 68 per thousand 22-year-olds in 1980 to 84 in 1989.

In 1989, almost 308,000 bachelors degrees were awarded in S&E fields; these represented about 30 percent of all degrees granted in the United States. Although the trend in overall S&E degree production varied considerably, S&E degrees as a fraction of total degrees did not change markedly over the decade.

Annual growth rates of bachelors degrees within major S&E fields differed widely over the decade. (See figure 2-5 and figure O-15 in Overview.) Between 1980 and 1989, the numbers of degrees awarded in the physical, environmental, and life sciences all declined; in contrast, computer science baccalaureates rose dramatically.

Shorter term growth rates reveal a somewhat different picture. In the latter part of the eighties, 1985-89, degree production increased in the social sciences and psychology but declined in virtually all major natural science fields and engineering.

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[5] Data are from Engineering Manpower Commission (1990). Enrollment data are collected on engineering programs approved by the Accreditation Board of Engineering and Technology. Upon successful completion of an engineering program, a student receives a bachelors degree or, in the case of a 5-year program, an engineering professional degree. Engineering technology programs are usually 2-year programs terminating in an associate degree; some technology programs, however, do offer 4-year programs of study.

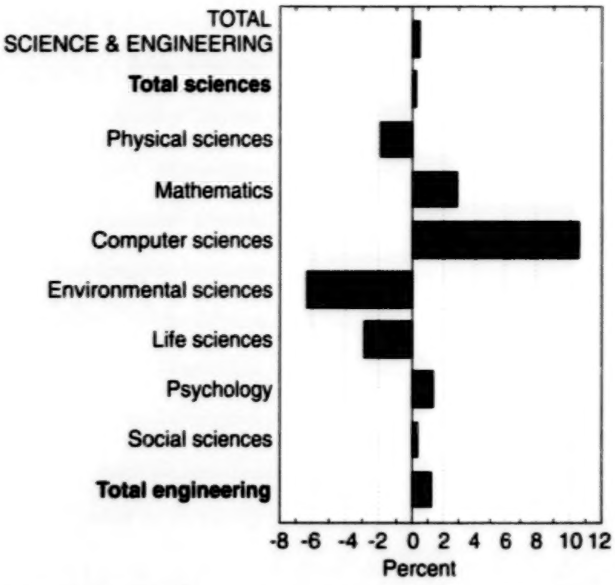
[6] Data for bachelors degrees in S&E used in this section are from the National Center for Education Statistics's Annual Survey of Earned Degrees; the data have been adapted to National Science Foundation field classifications. See SRS (1991).

In 1989, about four-fifths of the S&E baccalaureate degrees awarded were in science fields (240,000) and one-fifth in engineering (67,000). In the sciences, the largest fractions of degrees were in the social sciences (31 percent), life sciences (22 percent), and psychology (20 percent).

Using data on probable major field of study reported by incoming freshmen as a barometer of future degree production patterns indicates that current field trends may not continue.[7] Interest in the social sciences as a major field of study peaked in 1988, stemming an increase that began in 1982. On the other hand, interest in engineering, which was on the decline, began to rise. For a more detailed discussion of the relationship between bachelors degree production and the intended majors of American freshmen, see "Relationship Between S&E Baccalaureate Production and Freshman Intentions," p. 52.

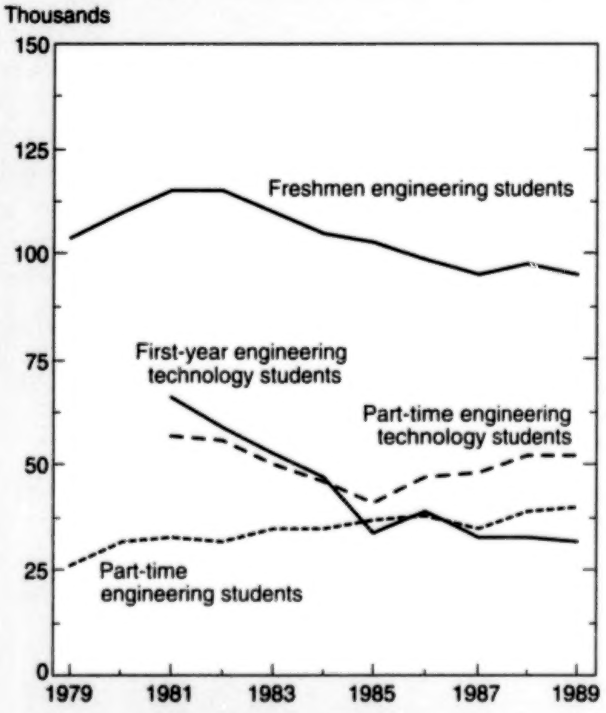
Degrees by Gender. The number of women earning bachelors degrees in S&E fields increased throughout the 1980s. This increase, coupled with a decline in S&E degree production among men since 1987, resulted in a rise in the representation of female degree-holders—from 36 to 40 percent between 1980 and 1989. Women account for higher shares of science than engineering degrees. For instance, in 1989, over 70 percent of psychology baccalaureates and more than 40 percent of those in mathematics, the life sciences, and the social sciences were awarded to women. In contrast, roughly 15 percent of 1989 engineering graduates were female.

Figure 2-5.
Annual change in science and engineering baccalaureates, by field: 1980-89



See appendix table 2-7. *Science & Engineering Indicators – 1991*

Figure 2-4.
Undergraduate enrollment trends for engineering and engineering technology programs



See appendix table 2-6. *Science & Engineering Indicators – 1991*

Although women made gains in all S&E fields between 1980 and 1989, the number earning degrees in some disciplines began to fall at the end of the decade. In fact, from 1988 to 1989, the S&E baccalaureates earned by women declined in all fields except psychology and the social sciences. The largest declines were in the computer sciences and engineering. Degrees earned by males experienced similar declines over the 2-year period.

Degrees by Racial/Ethnic Group.[8] In 1989, almost 34,000—10 percent—S&E bachelors degrees were granted to underrepresented minorities (blacks, Native Americans, and Hispanics). In 1979, this number was about 30,000 (9 percent of total degrees). Although the number of degrees granted to underrepresented minorities in general increased from 1979 to 1989, the number awarded to blacks changed very little, falling from 18,700 in 1979 to 18,400 in 1989. The rapid increases in engineering and computer science degrees earned by blacks over this period were countered by substantial declines in degree production in the life and social sciences and psychology.

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[7] Data are from the Higher Education Research Institute, University of California at Los Angeles, the American Freshmen Norm Survey, unpublished tabulations.

[8] S&E degree data by racial/ethnic group are for U.S. citizens and permanent residents.

Relationship Between S&E Baccalaureate Production and Freshman Intentions. This section discusses anticipated trends in degree conferrals in various undergraduate majors, a topic of interest for public policymakers and university officials. The discussion relies on intended majors reported by American first-time full-time freshmen; such data presage trends in subsequent bachelors degree conferrals, albeit more accurately in some fields than in others.[9]

To determine the relationship between freshman intentions and baccalaureate production in S&E, the actual proportion of all bachelors degrees in a given field was compared to the proportion of first-time full-time freshmen in 4-year institutions who indicated this field as their probable major. A 3-year lag time was found to best reflect the actual lag from freshman year to bachelors degree.[10]

As shown in figure 2-6, freshman intentions generally provide an accurate predictor of degree patterns in the natural sciences when computer science is excluded.[11] The less accurate "fit" in computer sciences may be attributable to differences in the characteristics of students who choose to major in this field. Computer science majors tended to be older than average: it is thus possible that a lower percentage of the students earning these degrees had been first-time freshmen 4 years earlier. Freshman intentions were not as accurate a predictor of absolute degree levels in engineering and the behavioral sciences, although they did serve as fairly successful leading indicators of trends.

Data on the actual number of bachelors degrees awarded are only available through 1989. Using a 3-year lag, these data can be used to suggest future patterns in bachelors degrees through 1994. This data projection suggests that the long-term decline in the proportion of bachelors degrees awarded in the natural sciences should bottom out in 1990 and start to recover in 1991. It also suggests that downturns in the proportions of computer science and engineering degrees will bottom out in 1991. Finally, the increased popularity in social science and psychology may peak in the 1991-92 period.

Graduate S&E Student Population

Recent Trends in Graduate Enrollments[12]

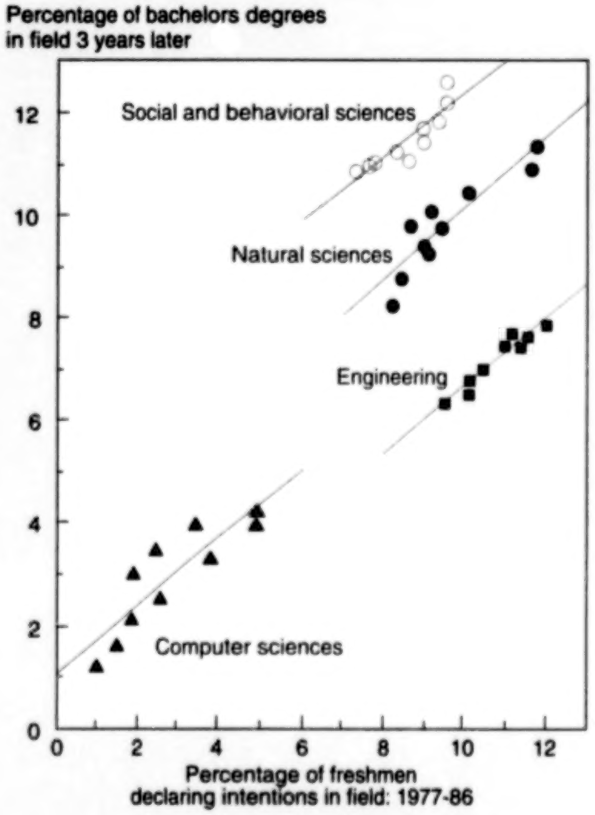
Graduate enrollment in S&E fields rose steadily at a rate of almost 2 percent per year throughout the eighties. By 1990, enrollment in these fields stood at about 401,600. Much of the growth in S&E graduate enrollments was driven by large increases in the numbers of women and non-U.S. citizens entering these programs. (See "Enrollments by Gender," p. 53, and "Foreign Students at U.S. Colleges and Universities," pp. 58-59.)

Enrollments in engineering rose much faster than in the sciences. Between 1980 and 1990, engineering enrollments increased at an annual rate of more than 3 percent compared to about 1 percent in the sciences. Much of this growth in engineering occurred in the first half of the eighties. Between 1986 and 1990, the annual growth rate in the sciences (1.8 percent) exceeded that in engineering (1.2 percent).

Over the long-term period, the only science field whose growth rate surpassed that of engineering was the computer sciences. Annual change among the other science fields ranged from a 0.3-percent decline (social sciences) to a 2.4-percent increase (mathematics).

In 1990, the science fields accounted for 73 percent of S&E enrollments, down from 77 percent in 1980. This change was a result of the rapid increases in engineering. The most dramatic proportional shift over the decade was the drop in the social sciences. About one in four graduate students was enrolled in social science programs in 1980; by 1990, the ratio had fallen to fewer than one in five.

Figure 2-6.
Freshmen intentions as predictors of science and engineering bachelors degrees



See appendix table 2-9. *Science & Engineering Indicators – 1991*

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[9] Data on choice of major by American freshmen were collected at a relatively aggregate level until 1977 (e.g., social and behavioral sciences) and subsequently at more disaggregate levels (e.g., subfields of social and behavioral sciences such as economics, political science, psychology, sociology, anthropology, and social work). This analysis is confined to data on freshman intentions since 1977.

[10] It might be expected that intentions expressed in the first few weeks of the freshman year would be best reflected in bachelors degree data of 4 or 5 years later. One interpretation of the appropriateness of the 3-year lag is that those factors that influence freshmen also influence sophomores, and most students do not have to commit to a major until their sophomore year.

[11] In general, correlation coefficients fell between 0.95 and 0.97.

[12] Data presented in this section are from the National Science Foundation's Survey of Graduate Science and Engineering Students and Postdoctorates. See SRS (forthcoming [b]).

First-Year Full-Time Enrollments. Slow growth in S&E enrollments overall may be partially explained by the very slow growth in first-year full-time enrollments. These students represented about 28 percent of all full-time S&E graduate students in 1990, down from 32 percent in 1982 (the earliest year for which comparable data are available). Between 1982 and 1990, first-year enrollments increased at only about half the annual rate of total full-time enrollments: 1.0 percent per year compared to 2.1 percent. First-year enrollments, however, began to turn sharply upward in 1989.

Part-Time Enrollments. In 1990, about one out of every three graduate S&E students was enrolled part time. Since 1982, these enrollments—like first-year full-time enrollments—have been increasing at a somewhat slower rate than overall enrollments: 1.4 percent versus 1.8 percent.

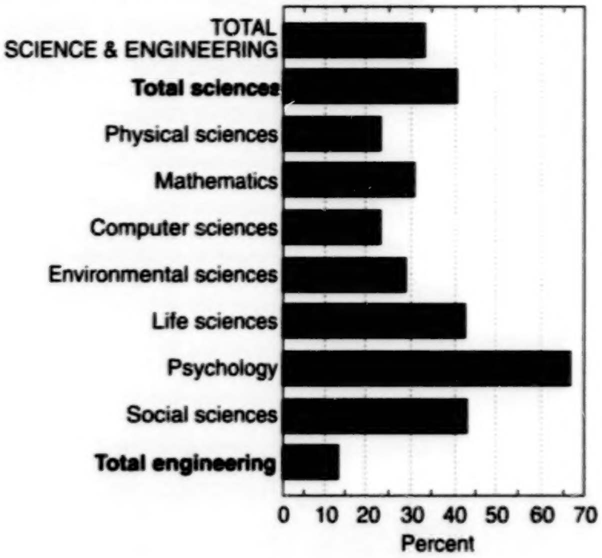
Compared to graduate enrollment overall, part-time students are more highly concentrated in engineering, the social sciences, and the computer sciences. These fields accounted for 32, 22, and 13 percent of part-time S&E students, respectively. Overall, respective shares for these fields were 27 percent, 20 percent, and 9 percent.

Enrollments by Gender. The number of women enrolled in S&E graduate programs rose significantly from about 94,800 in 1980 to almost 135,300 in 1990. By 1990, about 34 percent of graduate S&E students were female, compared to 29 percent in 1980. Representation of women varied by field, however. (See figure 2-7.) The highest increases by women were in those S&E fields in which they historically have been the most underrepresented: the physical sciences, computer sciences, and engineering. Annual growth rates in these fields were 5, 9, and 8 percent, respectively. For men, respective growth rates in these fields were lower than 2 percent, 9 percent, and 3 percent.

In contrast to the rapid growth in female S&E enrollment, enrollment of men grew very slowly overall and declined in several fields. For the 1980-90 period, the number of male graduate students rose about 1 percent per year; the number of females rose 3 percent annually. By field, decreases in the number of men pursuing graduate work occurred in the environmental, life, and social sciences and in psychology.

Enrollments by Racial/Ethnic Group.[13] The number of U.S. citizen blacks, Native Americans, and Hispanics in S&E graduate programs increased from 20,900 in 1983 (the earliest year for which comparable data are available) to 24,400 in 1990. This change represents a growth rate slower than that of overall enrollments (1.4 percent versus 1.7 percent) but faster than that of total U.S. citizens (0.8 percent). Proportionally, these groups accounted for about 8.2 percent of S&E enrollments of U.S. citizens in 1990, up from 7.5 percent in 1983. Growth patterns differed among racial/ethnic groups. (See figure 2-8.) Among blacks, for instance, enrollments declined until the mid-eighties and then turned upward; enrollment of Hispanics rose steadily throughout the decade.

Figure 2-7.
Women as a percentage of science and engineering graduate students: 1990



See appendix table 2-10. *Science & Engineering Indicators – 1991*

Underrepresented minorities were less likely to be enrolled in engineering than the sciences compared to other racial/ethnic groups. In 1990, 14 percent of blacks and 19 percent of Hispanics were in engineering programs, compared to 22 percent of white and 38 percent of Asian graduate students. Within science fields, blacks and Hispanics were more highly concentrated in the social sciences. (See appendix table 2-11.)

Masters Degree Production in S&E[14]

More than 66,000 persons earned masters degrees in S&E fields in 1989, representing about 21 percent of all masters degrees awarded in the United States. This proportion increased from 18 percent 10 years earlier. In the eighties, S&E masters degree recipients came to account for a larger fraction of the general population. In 1989, the number of S&E masters degree recipients per thousand 24-year-olds was 16, up from 13 in 1980.

Annual growth in S&E masters degree awards during the eighties was about 2 percent. By field, the rate in engineering (about 4 percent) was more than three times that registered in the sciences (1 percent). Among science fields, degree conferrals in the computer

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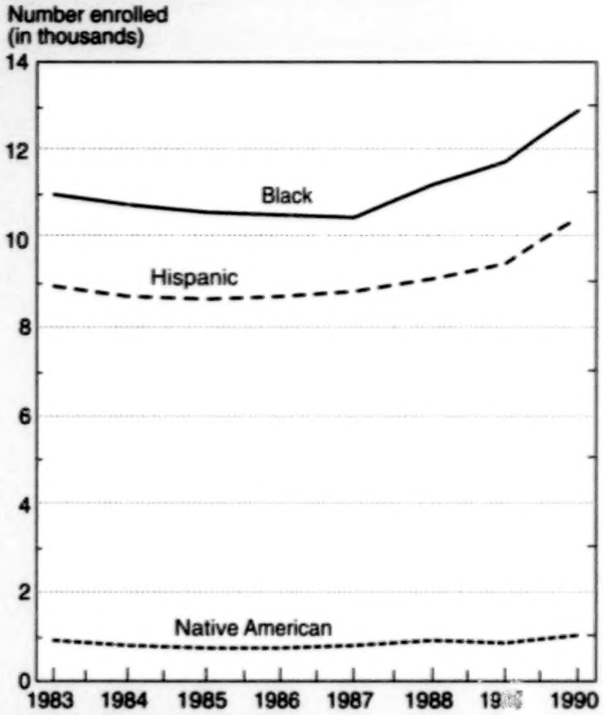
[13] Data on S&E graduate enrollment by racial/ethnic group are only available for U.S. citizens.

[14] Data for S&E masters degrees are from the National Center for Education Statistics's Annual Survey of Earned Degrees; the data have been adapted to National Science Foundation field classifications. See SRS (1991).

Figure 2-8.
Racial/ethnic minority enrollment in science and engineering graduate programs



NOTE: Data are for U.S. citizens only.

See appendix table 2-11. *Science & Engineering Indicators – 1991*

sciences experienced the highest growth (10 percent per year) over the decade, although this growth slowed toward the end of the decade. For example, from 1988 to 1989, degrees in this field were up less than 3 percent. In comparison, growth in science fields that had been slow throughout most of the decade began to turn upward more rapidly by the end of the eighties. For example, between 1980 and 1989, degrees in the physical sciences and psychology each rose at an annual rate of about 1 percent; over the 1988-89 period, growth in these fields increased 4 percent and 9 percent, respectively.

Engineering degrees account for a greater percentage of the degrees at the masters level than at the doctorate level. (See figure 2-9.) In 1989, masters degrees in engineering represented about 36 percent of all S&E masters degrees; the computer sciences represented the largest portion of masters degree awards (14 percent) among the science fields.

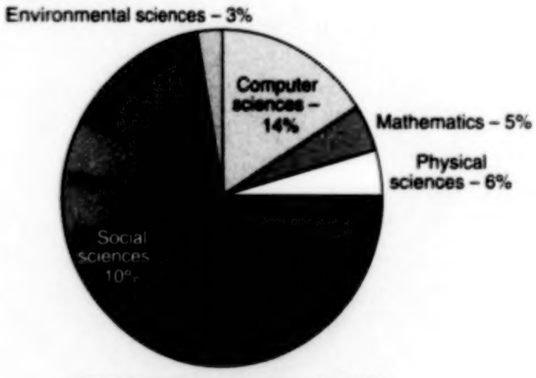
Degrees by Gender. As with baccalaureate production and S&E graduate enrollment, the number of women earning masters degrees rose faster than men. Degrees for women increased at an annual rate of 3.7 percent per year compared to a 1.2-percent rate for men. In 1989, about 31 percent of S&E masters degrees were granted to women, up from 26 percent in 1980.

Women were much more likely than men to earn their degrees in science rather than engineering. They were also more concentrated in psychology and the life sciences. For example, in 1989, about 28 percent of women—compared to 6 percent of men—were granted masters degrees in psychology. In the life sciences, the percentages were 17 and 11, respectively.

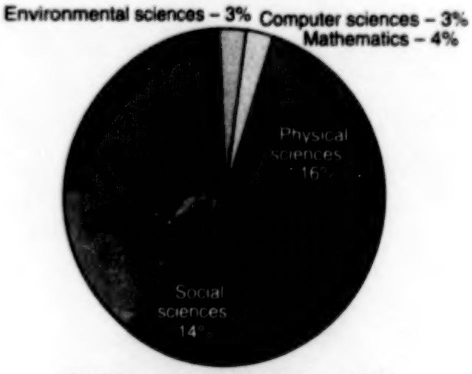
Degrees by Racial/Ethnic Group.[15] Almost 3,500 S&E masters degrees—7 percent of total—were earned by blacks, Native Americans, and Hispanics in 1989. Differences in growth patterns by the individual minority groups existed. For example, between 1979 and 1989, the number of blacks earning masters degrees in S&E fell from 2,000 to fewer than 1,700; concurrently, there was a steady increase among Hispanics, whose numbers grew from 1,000 to about 1,600.

By S&E field, about 46 percent of blacks earned their degrees in either psychology or the social sciences; another 24 percent earned their masters degrees in engineering.

Figure 2-9.
Science and engineering masters and doctorate degrees, by field



66,000 masters degrees in 1989



22,700 doctorate degrees in 1990

See appendix tables 2-14 and 2-16.
Science & Engineering Indicators – 1991

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[15] Data on masters degrees by racial/ethnic group are for U.S. citizens and permanent residents only.

These distributions changed substantially during 1979-89. For instance, in 1979, about 62 percent of blacks earned degrees in psychology and the social sciences, and 12 percent were granted engineering degrees.

Doctorate Degree Production in S&E[16]

The rate of growth in the number of S&E doctorates awarded exceeded that of total doctorate production between 1980 and 1990. The respective annual growth rates were 2.4 percent and 1.4 percent. In 1990, almost 22,700 S&E doctorates were awarded, representing over three-fifths of total doctorate production by U.S. universities and colleges.

As at the baccalaureate and masters degree levels, degrees in engineering rose faster over the decade than those in the sciences (8 percent versus 5 percent). Much of the growth in engineering was attributable to significant numbers of foreign citizens earning these degrees. (See "Foreign Students at U.S. Colleges and Universities," pp. 58-59). Doctorate awards in engineering were up about 6.4 percent per year over the 10-year period; in science fields, the rate was 2.4 percent. Growth in degree production accelerated in the latter half of the decade for both engineering and science.

Within science fields, degrees in the computer sciences showed the highest growth with an annual rate of 11 percent. The next highest growth rate was held by the physical sciences which registered a 3-percent annual increase. Degrees in psychology and the social sciences each rose fewer than 0.5 percent per year during the 10-year period.

Degrees by Gender. In 1990, about 28 percent of S&E doctorates were granted to women, up from 22 percent a decade earlier. The fastest growing fields for women were the computer sciences and engineering. Despite rapid growth in these fields, however, almost three-quarters of female degree recipients earned degrees in psychology and the life and social sciences in 1990.

Of the more than 13,000 Ph.D. degrees earned by women in 1990, almost half were in S&E; of these S&E doctorates, almost three-fifths were in either the life sciences or psychology. Engineering degrees accounted for 7 percent of the S&E degrees awarded to women. Men, in contrast, were much more likely to earn their S&E doctorates in engineering (27 percent).

Degrees by Racial/Ethnic Group.[17] The number of S&E doctorates awarded to underrepresented minorities in 1990 was 831, or 6 percent of all S&E doctorates. Ten years earlier, this number was 559, or 4 percent of total. Virtually all of this growth resulted from an increase in the number of Hispanics earning S&E doctorates: 213 in 1980 to 451 in 1990. Among blacks, S&E Ph.D. awards rose from 319 to 340 over the decade.

Blacks and Hispanics are much more heavily concentrated in the sciences than in engineering. In 1990, nearly 9 of every 10 S&E doctorates earned by members of these groups were in the sciences. The largest fractions of these science degrees were in psychology and the social sciences.

Time to Degree.[18] The number of S&E graduate students depends partly on the time it takes doctoral students to complete their Ph.D. degrees. Time to degree also influences students' decisions to enter and complete doctoral training. For people who received both baccalaureate and doctoral degrees from U.S. institutions, the average elapsed time between the dates of their bachelors and doctorate degrees increased unevenly in 10 of 11 S&E fields during the 1981-89 period. (See figure 2-10.) The time gap between degrees continued to grow in 7 of these 11 fields over the last 3 years of that period. From 1974 to 1981, only the social and behavioral science fields showed increases in elapsed time, but during 1968-74 all fields experienced a sharp upward rise averaging 0.7 years. For all S&E fields combined, average time to degree rose by 1.6 years during 1974-89; concurrently, time enrolled in graduate school rose by 1.1 years.

A 1989 National Science Foundation (NSF) study found that this rise in lag time for S&E doctorate awards was *not* the result of factors usually associated with such a rise—i.e., reduced financial aid (particularly fellowships), marital status, quality of the doctorate-granting institution, and gender.[19] Nor did changes in the aggregate tendency to switch fields after the bachelors or masters degree, switch institutions, or acquire a masters degree explain these increases. Although many of these factors were found to be important influences on an individual's time to degree, their *aggregate* influence was minor.

Instead, the study found that changes in the real value of starting salaries for doctorate-holders and the percentage of new doctorate recipients taking postdoctoral positions were highly correlated with the increased average time to degree. The percentage taking postdoctoral appointments rose from 21 to 48 during the 1968-84 period. This finding does not mean, however, that postdoctoral appointments were the direct source of increased time to degree, but rather that the rising fraction taking these appointments represents a reduced incentive for all doctoral students to complete their degree work aggressively.

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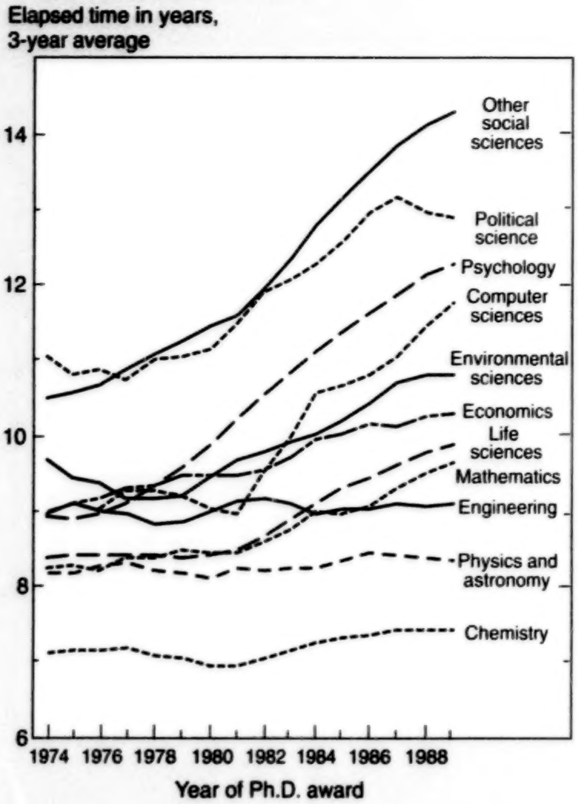
[16] Information on S&E doctorates granted in the United States are from the National Science Foundation's Survey of Earned Doctorates. See SRS (forthcoming [a]).

[17] Data reflect U.S. citizens and permanent residents only.

[18] "Time to degree" is the term used in NRC (1989). The annually representative time to degree has been calculated both as a median and as an average. See, for example, Bowen and Sosa (1989) and Nerad and Cerny (1991).

[19] The study covered 184,000 new S&E Ph.D. recipients (the majority of the new doctorates awarded from 1958 to 1987 in seven S&E fields). See PRA (1990), pp. 227-32.

Figure 2-10.
Trends in elapsed time from bachelors to Ph.D. degrees, for selected fields



See appendix table 2-18. *Science & Engineering Indicators – 1991*

Another factor was also recently identified as a definite source of the increase in time to degree.[20] Studies have found that if the number of graduate students entering doctoral programs declines for a period of time—which has been the case in several S&E fields—the eventual consequence of this decline is to increase the percentage of "slow finishers" among future Ph.D. graduating classes. The proportion of Ph.D. recipients in the social and behavioral sciences who required 10 or more years of elapsed time to finish their doctorates rose from 35 percent in 1974 to 60 percent in 1989; this proportion remained at 25 percent in engineering, chemistry, and physics.

Several fields experiencing increases in time to degree during 1974-81 also experienced large declines in the (approximate) percentages of bachelors recipients who were completing doctoral work. In these fields, these declining percentages indicate that new students may have been discouraged about pursuing further study, especially those who had the bulk of their time investment ahead of them. Since the early eighties, however, there has been no further tendency for doctorate awards to decline as a percentage of bachelors degree production in eight of the nine fields shown. (See figure 2-11.)

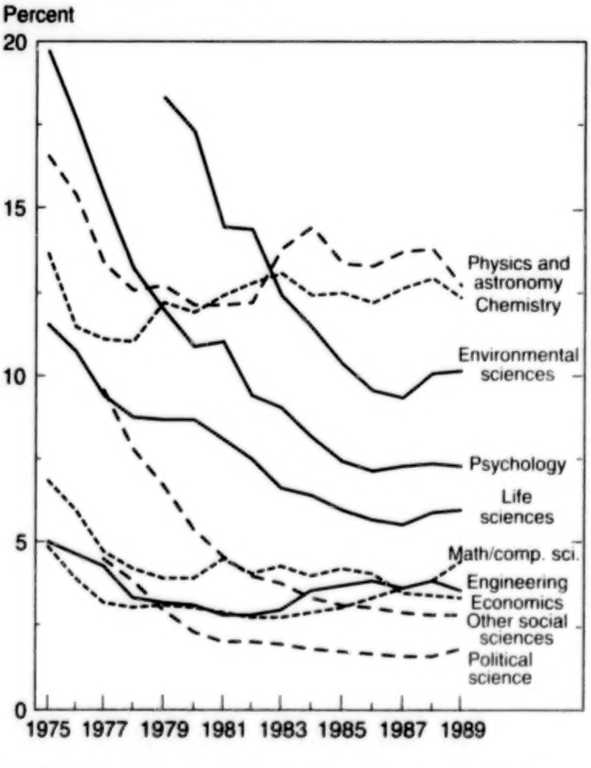
Major Sources of Financial Support

Indicators of the health of undergraduate and graduate education are changes in patterns of support from Federal and other sources, the choices available among mechanisms of support, and—at the graduate level—in the number of Federal agencies that provide graduate S&E student support. These indicators are described in the following paragraphs.

Financial Support Reported by College Freshmen[21]

During the eighties, American freshmen relied increasingly on their parents or other relatives for financing their education. In 1990, more than three-fifths of freshmen who planned to major in an S&E field reported receiving $1,500 or more from these sources, up from fewer than two-fifths in 1980.[22] This trend was also evident among freshmen planning to major in non-S&E fields: The number of students reporting reliance on this source of support rose from 39 to 61 percent.

Figure 2-11.
Ratio of Ph.D. awards to bachelors degrees lagged by average time to degree



NOTE: Time to degree by field and year as shown in figure 2-10.

See appendix table 2-19. *Science & Engineering Indicators – 1991*

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[20] This discovery was made both within NSF and by Bowen and Sosa (1989).

[21] Data in this section are from the Higher Education Research Institute, University of California at Los Angeles, the American Freshmen Norm Survey, unpublished tabulations.

[22] Note that the $1,500 lower limit used in the American Freshmen Norm Survey has not been adjusted for inflation. In constant 1990 dollars, this $1,500 in 1990 represented about $440 in 1970.

Two other sources that grew in importance over the decade were students' personal savings (7 percent to more than 17 percent) and college grants and scholarships (7 percent to almost 19 percent). Throughout the decade, the fraction that reported Federal loans as a source of financing remained about the same. Around 18 percent of American freshmen reported receiving at least $1,500 from either Federal guaranteed student loans or national direct student loans in both 1980 and 1990.

Support of S&E Graduate Students[23]

Graduate students are less likely than undergraduate students to finance the largest fractions of their education from personal or family resources. Federal and institutional sources play a much more prominent role in financing their studies.

Sources of Support. Three broad categories of support represent the majority of the reported funding sources for graduate S&E students:

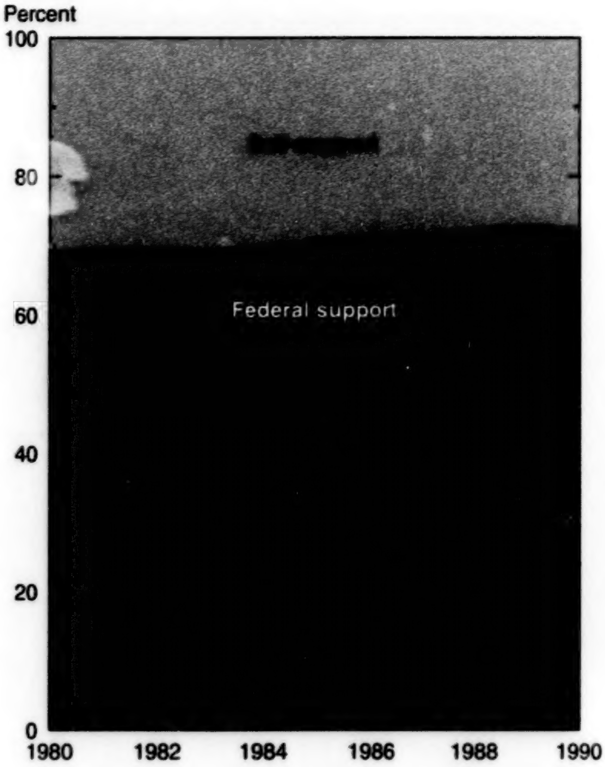
- Federal sources,
- Non-Federal sources such as academic institutions and private industry, and
- Self-support.

Of these, non-Federal sources of support increased most rapidly, registering an annual rate of about 3 percent, during the 1980s. (See figure 2-12.) For comparison, total full-time S&E graduate enrollment increased about 2 percent per year between 1980 and 1990. (See appendix table 2-20.) Increased support from non-Federal sources played the most crucial role in engineering and the computer sciences.

Federal support of graduate S&E students declined somewhat during the early eighties but turned strongly upward by mid-decade for some fields. This late eighties increase in Federal support was most evident in engineering, the life sciences, mathematics, and the computer sciences. Between 1986 and 1990, annual rates in these fields ranged from 4 percent (engineering and life sciences) to almost 8 percent (mathematics).

Not all fields, however, were affected by the resurgence in Federal support. In the social and environmental sciences, for example, the number of federally supported graduate students continued to decline as sharply as it had in the early eighties. Moreover, increases in support from non-Federal sources for these fields did not keep pace with declines in Federal sources of funding.

Figure 2-12.
Trends in sources of financial support for science and engineering graduate students



See appendix table 2-20. *Science & Engineering Indicators – 1991*

Different growth patterns in support sources resulted in a shift in the mix of these sources between 1980 and 1990. The proportion of students who reported support from non-Federal sources rose from 48 to 53 percent. Overall, the fraction of students who received Federal support fell slightly, dropping from 21 to 20 percent. Percentages varied, however, by science field. The proportional change in self-support over the decade was from 31 to 27 percent.

Mechanisms of Graduate Student Support. Mechanisms of financial assistance fall into four major categories:

- *Fellowships*—usually received directly by students from sources other than the academic institution,
- *Traineeships*—competitive awards usually given by the institution,
- *Teaching assistantships*, and
- *Research assistantships.*

During the 1980-90 period, the highest growth rate among support mechanisms was for research assistantships, which increased at an annual rate of more than 4 percent. As a result of this growth rate, the share of graduate students supported by this mechanism increased from 23 to 29 percent. Fellowships and teaching assistantships each rose about 2 percent a year. Finally, the number of traineeships declined until about 1986; by 1990, however, the number of students supported by this mechanism had almost recovered its 1980 level.

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[23] Many students fund their graduate education using several different sources of financial aid, some of which are not reported. Consequently, although the data in this section represent a *majority* of support sources, they do not represent *all* sources.

Data in this section on sources and mechanisms of support among graduate S&E students are for those enrolled full time. See SRS (forthcoming [b]).

Types of support mechanism differ among major S&E fields. In 1990, research assistantships supported the largest portion (roughly two-fifths) of students in the physical, environmental, and life sciences and in engineering. Teaching assistantships made up the bulk (about 56 percent) of support received by mathematics students. In contrast, other sources of support (a category including, for example, Federal student loans) accounted for the largest shares of support for students in psychology (59 percent) and the social sciences (48 percent).

Support Mechanism by Source. Types of support mechanisms also vary between Federal and non-Federal sources. (See figure 2-13.) For example, Federal agencies provide a majority of their support in the form of research assistantships. In 1989, more than four of five students funded by NSF were supported by research assistantships.[24] Comparatively, 28 percent of those receiving non-Federal support were on research assistantships; 45 percent held teaching assistantships.

Shifts occurred over the 1980-89 period in the types of support mechanisms used by the Federal and non-Federal sectors. In general, research assistantships increased in significance for both sectors. Concurrently, federally sponsored traineeships and nonfederally funded fellowships and teaching assistantships dropped off. (See appendix table 2-22.)

Support of Recent Ph.D. Recipients.[25] Graduates of doctoral S&E programs were supported by a number of different sources, primarily by universities. For example, of the 22,700 persons who earned Ph.D. degrees in S&E fields in 1990, over 18,100 reported at least some financial support from their institutions. Research and teaching assistantships were chief among the mechanisms of university support.

Academic institutions were cited as the major support source by Ph.D. recipients in all S&E fields. By field, this source played a somewhat larger role in financing degree programs in natural science fields; new doctorate recipients in psychology were less likely to rely on institutional support.

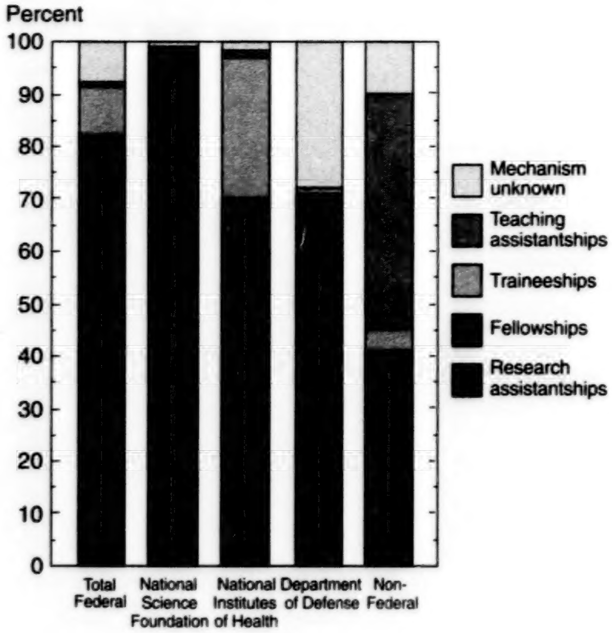
Among other support sources, roughly 9,000 of the 22,700 new S&E doctorate recipients indicated that their own earnings supported a portion of their education. Ph.D. degree recipients in psychology were most likely to rely on self-support.

International S&E Education

Viewing higher education in science and engineering internationally may be done from a number of perspectives. This section presents two aspects of this topic. First, the number of foreign students studying in U.S. universities and colleges is examined. Second, comparisons in baccalaureate production in natural science and engineering degrees are made across several different countries.

Figure 2-13.

Types of financial support mechanisms provided to 1989 science and engineering graduate students, by source



See appendix table 2-22. *Science & Engineering Indicators – 1991*

Foreign Students at U.S. Colleges and Universities

Graduate S&E Enrollment. Participation of foreign citizens in S&E graduate programs at U.S. academic institutions rose dramatically during the eighties from about 20 percent of the total in 1983 (the earliest year for which comparable data are available) to 26 percent in 1990. There were almost 102,500 foreign students enrolled in S&E graduate study in 1990, up from 70,600 7 years earlier. In comparison, the number of U.S. citizens enrolled rose from about 279,000 to almost 299,100.

By field, foreign enrollment grew fastest in the computer, physical, and life sciences. Annual growth in these fields was between 7 percent (physical sciences) and 10 percent (computer sciences) during the 7-year period. At about 3 percent per year, the slowest growth rate was in the social sciences. Enrollment of U.S. citizens increased fastest in the computer sciences (4 percent). These differing growth patterns resulted in a higher representation of foreign students in almost all S&E graduate programs. (See figure 2-14 and figure O-17 in Overview.)

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[24] Information for 1990 on support mechanism by source was not available as of this writing.

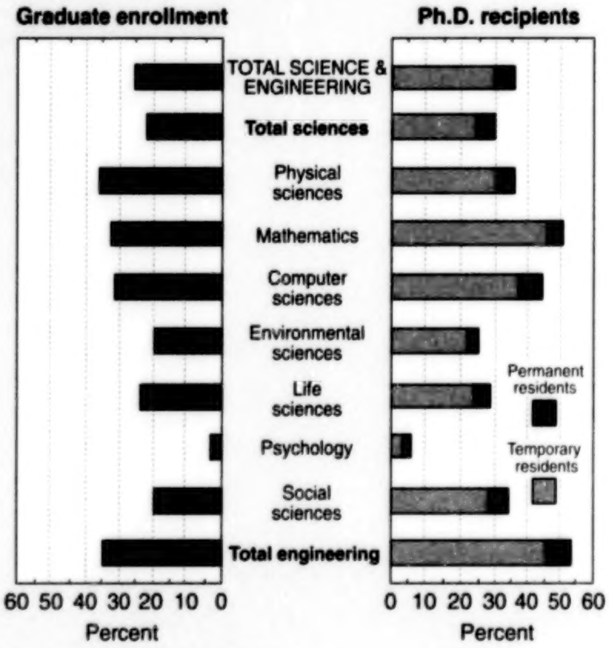
[25] Data in this section are from NSF's Survey of Earned Doctorates, unpublished tabulations.

Foreign citizens tend to be concentrated in different fields of study than are U.S. citizens. For example, almost 37 percent were enrolled in engineering compared to 24 percent of U.S. citizens in 1990. Similarly, foreign students were more often in physical and computer science studies; U.S. citizens tended more toward the life and behavioral sciences. Thus, about 16 percent of U.S. graduate students were in psychology programs; less than 2 percent of foreign enrollment was in this field.

S&E Doctorate Recipients. Data on new S&E doctorate recipients reveal a more detailed picture of participation by foreign citizens in U.S. graduate education. Much of the increase in S&E doctorate production during the eighties was attributable to increases in the number of temporary residents earning these degrees. Between 1980 and 1990, the number of S&E doctorates granted rose from 17,500 to 22,700. Degrees to temporary residents accounted for almost 70 percent of this increase. By 1990, about 28 percent of Ph.D. program graduates were on temporary visas; another 5 percent held permanent visas.

The representation of foreign citizens among S&E doctorate recipients varies considerably by field of degree. (See figure 2-14.) About one of every two Ph.D. recipients in mathematics and engineering studied in the United States on a temporary visa. In contrast, only about 1 in 20 Ph.D. recipients in psychology was a temporary resident.

Figure 2-14.
Foreign citizen representation in 1990 U.S. science and engineering graduate education



See appendix tables 2-23 and 2-24.
Science & Engineering Indicators – 1991

Comparisons of U.S. and non-U.S. citizen growth rates and distributions of doctoral degrees by S&E field reveal a pattern similar to that of S&E graduate enrollment. During the eighties, annual growth rates in the numbers of temporary residents exceeded those of U.S. citizens in all fields. For U.S. citizens, the numbers earning degrees in mathematics, the life sciences, psychology, and the social sciences showed declines. By S&E field, temporary residents were much more likely to receive degrees in engineering than were U.S. citizens. In 1990, about 35 percent of temporary residents and 14 percent of U.S. citizens earned their degrees in this field.

Most of the foreign citizens earning S&E doctorates are Asian. About 64 percent of temporary residents in 1990 were Asian; 23 percent were white. These proportions have changed significantly over the last decade. In 1980, about 45 percent of temporary residents were Asian and 34 percent were white.

International Comparisons in Higher Education

Educational trends over the last 15 years in four world regions reflect a shift in global human resources for science from developed to developing countries.[26] Available data on bachelors degrees in natural science and engineering fields illustrate this shift.[27] (See figure 2-15.) Developing countries such as China are producing a growing share of the world's NS&E degrees.[28]

According to these data, the Asian region (even considering only six countries) surpassed the USSR region after 1986 in production of NS&E bachelors degrees. In engineering, the USSR is still the highest regional producer of bachelors degrees in the world. In the natural sciences, North America and the USSR have both declined slightly in the last few years, while Asia and Europe have increased in annual degrees.

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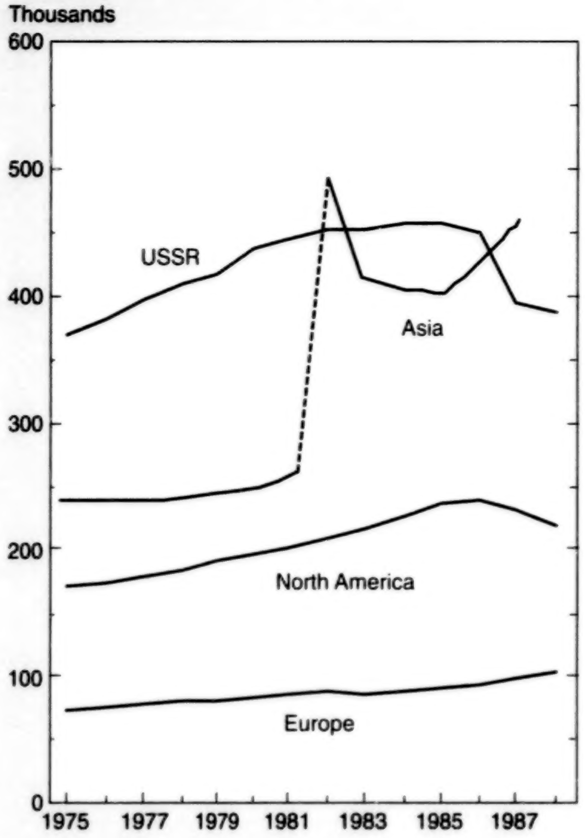
[26] Data in this section on degrees by country are for NS&E fields only. Natural science fields include mathematics and the physical, biological, environmental, agricultural, and computer sciences.

Countries in North America for which data were available for comparisons include the United States and Canada; Western European countries include France, Italy, Sweden, the United Kingdom, and West Germany (West German degree data do *not* include data for East Germany). Selected Asian countries include China, India, Japan, Singapore, South Korea, and Taiwan. The USSR contains all 15 republics. Therefore, the comparisons are among limited data sets of three world regions and one complete region (the USSR).

[27] The data base used here was developed from 15-year time series on university enrollments and graduates in NS&E fields, obtained from UNESCO's Division of Statistics. UNESCO data were updated and adjusted, and missing years added, with national educational statistics from each country over the same time period (1975-89). (See "References," pp. 62-63, for country data sources.) National statistics were then reclassified using NSF field taxonomies. In this chapter, first university degrees of other countries are referred to as bachelors degrees.

[28] Some of the increase in Asian bachelors degrees in the early eighties reflects the Chinese universities reopened in the late seventies and the surge of young people who entered universities or returned to complete science programs that had been interrupted during the Cultural Revolution.

Figure 2-15.
Bachelors degrees in natural science and engineering, by selected world region



NOTES: USSR = all 15 republics; Asia = China, India, Japan, Singapore, Korea, and Taiwan (data for China are not available prior to 1982); North America = United States and Canada; Europe = France, West Germany, Italy, United Kingdom, and Sweden.

See appendix table 2-25. *Science & Engineering Indicators – 1991*

Grouping countries by stage of development rather than by geographic region highlights differences in bachelors degree growth rates. (See text table 2-2.) During 1975-88, five Asian developing countries more than doubled their annual number of NS&E bachelors degrees awarded. The developed countries increased their annual bachelors degrees by 16 percent. In 1988, the developed countries led in the share of bachelors degrees. However, given demographic patterns in Asian countries, they have the capacity to reverse this order and rapidly surpass developed countries in human resources for science.

Bachelors Degrees in the Natural Sciences. The USSR and the United States show declines in natural science graduates over the 15-year time period. (See figure 2-16.) Canada is steadily increasing in natural science graduates. Within Europe, only the United Kingdom has declined in natural science degrees since 1982. All other European countries have grown in natural science degrees.

The high number of bachelors degrees in the natural sciences in Asia is largely accounted for by India. India is the world's foremost educator of natural scientists; since the early seventies, it has annually produced more bachelors degrees in these fields than has the United States. India's preference for basic sciences is shown in the high ratio (0.26) of natural science degrees to total degrees. (See appendix table 2-28.) China will also be a main producer of natural science degrees for the Asia region. With about 40,000 degrees annually, China produces slightly fewer than one-third of the degrees that India produces.

Bachelors Degrees in Engineering. In the USSR, most higher education degrees are given in technical fields: about 36 percent of all degrees granted in this country were in engineering in 1988. In 1986, engineering degrees began to decline annually in the USSR, but there are still over 280,000 such degrees granted per year. (See figure 2-17.) These engineering graduates receive technical training in highly focused engineering subspecialties, such as industrial lathes. This training is very different from the general and theoretical engineering education of other countries, where engineering principles can be applied to new products and processes.

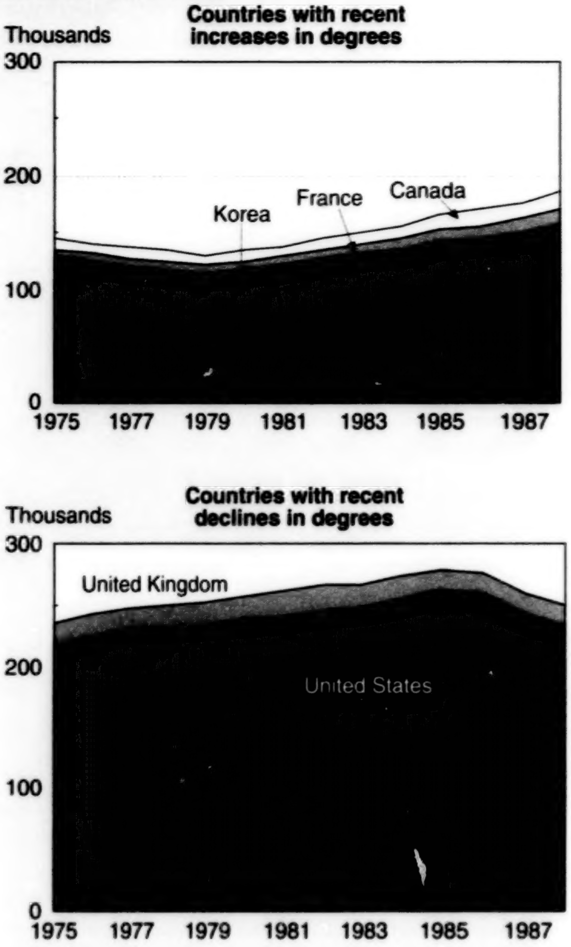
Text table 2-2.
Annual growth rates in natural science and engineering NS&E degrees in developed and developing countries: 1975-88

	NS&E	Natural science	Engineering
		Percent	
Total	3.0	2.4	2.9
Developed countries	1.1	1.1	1.2
Canada	4.2	4.1	4.3
France	4.0	4.9	3.5
Italy	1.8	1.2	1.3
Japan	0.9	1.4	0.8
Sweden	2.7	3.2	2.5
United Kingdom	-0.5	-0.3	-8.0
United States	2.5	1.0	5.0
West Germany	5.3	5.6	5.9
USSR	0.8	0.6	0.3
Developing Asian countries	5.2	4.1	6.6
China	6.9	5.0	7.8
India	3.3	3.0	5.3
Singapore	11.0	8.1	14.4
South Korea	11.3	11.2	11.1
Taiwan	3.6	3.8	3.7

NOTE: Growth rates were computed with time trends on latest available 10 to 15 years of data; for developing Asian countries total and for China, growth rates were computed with time trends on last 5 years.

See appendix table 2-25 *Science & Engineering Indicators – 1991*

Figure 2-16.
Trends in natural science bachelors degrees, by selected country



See appendix table 2-25. *Science & Engineering Indicators – 1991*

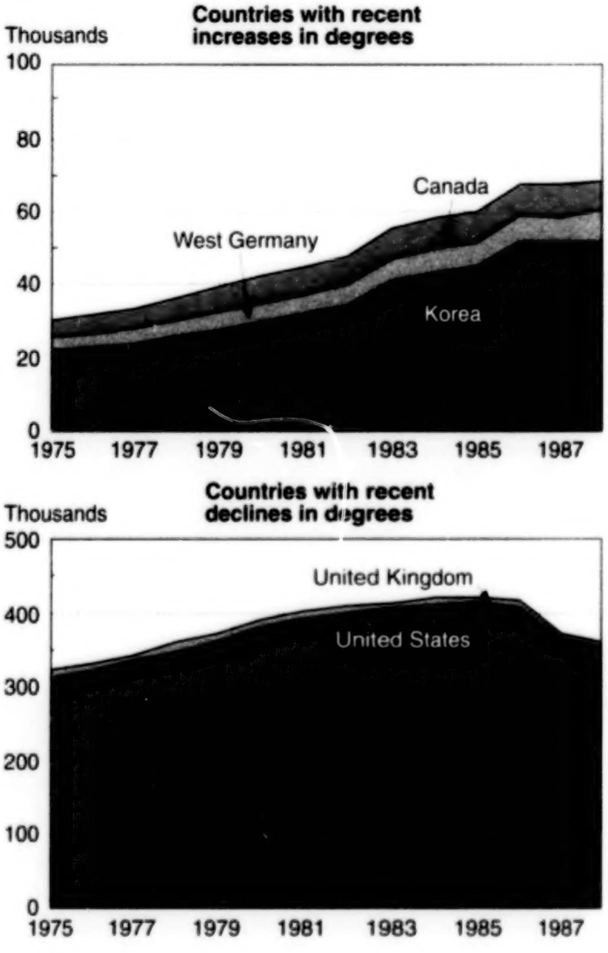
Both Canada and the United States peaked in engineering degree production in 1985, and their numbers have since been decreasing. In European countries, only the United Kingdom has declined in engineering graduates. Europe overall, like Asia, has increased its number of graduates, but from a smaller base than Asia.

China and Japan are the main producers of engineering degrees for the Asian region. China has the highest number, with 93,000 graduates in 1987. Japan has the second highest production of engineers, with 77,000 graduates that same year. However, Japan has been producing approximately this number of engineering graduates for over 10 years, whereas the number of degrees in China is beginning to increase. In South Korea, the increasing number of engineering degrees has recently leveled off; for the past 3 years its degrees have remained stable.

Demographics. The share shift in global human resources for science in these four world regions is reflected in the demographic trends of their 20- to 24-year-olds. (See appendix table 2-27.) Almost every country that increased its production of bachelors degrees in natural science and engineering did so with a growing college-age population. Only West Germany managed to increase NS&E degree production (5-percent growth rate over 15 years) with a declining college-age population since 1985.[29] The United States, the USSR, and the United Kingdom had a smaller pool of 20- to 24-year-olds and a falloff in technical degree production. The decline in college-age population in the USSR ended in 1990.

Participation Rates in S&E Education. Among all countries, the USSR had the highest percentage of 22-year-olds who received bachelors degrees in natural science or engineering. (See figure 2-18.) Even with a slight decline over the last few years, over 8 percent of this age group in the USSR received technical degrees. Among Western countries, the United States had the next highest percentage of technical degree recipients among its

Figure 2-17.
Trends in engineering bachelors degrees, by selected country



See appendix table 2-25. *Science & Engineering Indicators – 1991*

young people, approximately 5 percent. The United Kingdom dropped its participation rate in technical degrees during the eighties from 4 to 3 percent. France, Italy, and West Germany increased the percentage of their young people receiving technical degrees from between 1 and 2 percent to between 2 and 3 percent.

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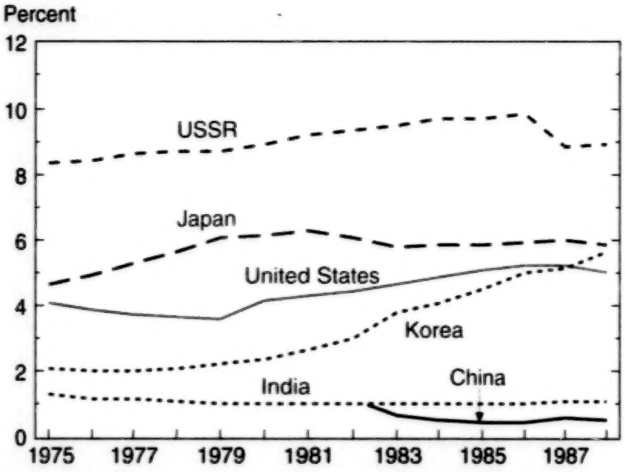
[29] West German demographic data combine the 20- to 24-year-old age groups of the united Germany. West German degree data, however, are for the former West Germany only.

Japan's high percentage of young people obtaining NS&E degrees (6 percent) fell slightly in the last few years, as both preferences for natural science and engineering and the college-age population declined. Most Asian developing countries increased the percentage of 22-year-olds receiving NS&E baccalaureates over the 15-year time period. South Korea dramatically increased its NS&E degrees from 2 to 6 percent of its young people. Taiwan increased its NS&E degree awards from 2- to 3-percent for its college-age population over the last decade.

China and India, with their huge populations, are maintaining their participation rates of 0.5 percent and 1.09 percent, respectively. If China and India continue to maintain these rates, global human resources for science would be greatly augmented.

Figure 2-18.
Natural science and engineering bachelors degrees as a percentage of 22-year-olds, by selected country



See appendix table 2-26. *Science & Engineering Indicators – 1991*

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Science and Engineering Workforce

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Science and Engineering Workforce

HIGHLIGHTS

Industrial Job Patterns

- **Employment growth of scientists and engineers in nonmanufacturing industries, primarily the services-producing industries, outpaced that in manufacturing during much of the 1980s.** Between 1980 and 1989, the number of science and engineering (S&E) positions in nonmanufacturing industries rose at an average rate of 4.5 percent annually, reaching 920,000 in 1989. Manufacturing industries also increased their utilization of S&E personnel. Between 1980 and 1989, the number of S&E positions in manufacturing industries increased at an average annual rate of 3.2 percent. *See pp. 68, 69.*

- **The 1980-89 S&E job growth in manufacturing and nonmanufacturing has stemmed from different factors.** In nonmanufacturing, S&E occupations increased their share of total jobs (from 1.4 percent in 1980 to 1.5 percent in 1989) and also benefitted from substantial economic growth as reflected in a 31-percent increase in total jobs. As a result, S&E job opportunities in nonmanufacturing increased by almost 50 percent during the eighties. In manufacturing, growth in S&E positions stemmed from an increased share of declining total manufacturing jobs. *See pp. 68, 69.*

- **Computer specialists, the fastest growing major S&E occupational group over the decade, reached 318,000 in 1989—more than all other scientist occupations combined.** Computer specialists almost doubled their numbers in both manufacturing and nonmanufacturing industries (to 103,000 and 216,000, respectively). Most of this growth was due to the rapid expansion of the business services industries, primarily computer and data processing services. *See p. 70.*

- **Over 60 percent of the 1.35 million private industry engineers were employed in the manufacturing sector in 1989.** However, the nonmanufacturing sector had a higher average annual growth rate in engineering jobs over the 1980-89 decade than did manufacturing—4.5 versus 3.2 percent. Electrical/electronic engineering was the largest specialty in both manufacturing (where it accounted for 32 percent of the sector's total engineering jobs) and nonmanufacturing (33 percent). *See p. 70.*

Demographic Trends in S&E Employment

- **In 1990, the median annual salaries of recent female baccalaureate recipients employed as scientists and engineers were approximately 73 percent of the salaries of their male counterparts.** This difference in salaries is largely due to the concentration of women in relatively low-paying scientific fields. In fact, for many of the engineering fields, women report higher salaries than men. *See p. 74.*

- **In 1989, the population of doctoral scientists and engineers was about 485,000, an increase of 4 percent per year since 1977.** Over this period, the annual rate of retirement for doctoral scientists and engineers increased from about 0.5 percent between 1977 and 1979 to 0.8 percent between 1987 and 1989. The effect of this change was a dramatic increase in the proportion of the doctoral scientist and engineer population who were retired—from 3.2 percent in 1977 to 5.6 percent in 1989. Most of this increase occurred after 1985, when retirees accounted for 3.5 percent of the S&E doctoral population. *See pp. 75-76.*

- **Doctoral scientists and engineers had little trouble finding work during the 1977-89 period; their reported unemployment rate ranged from 1.2 percent in 1977 to less than 1 percent in 1989.** By contrast, the overall unemployment rate in the United States was 5.3 percent in 1989, while for professional workers it was 1.7 percent. The rate for scientists and engineers at all degree levels combined was 1.5 percent in 1988. *See p. 76.*

Labor Market Supply and Demand

- **The 1990s should be a period of relative stability in overall S&E labor markets.** In contrast, during the early to mid-1980s, many S&E fields experienced temporary shortages due to the defense buildup of the period. Various demand scenarios have been processed to examine how alternative national economic growth patterns might affect S&E employment. Supply side simulations have been run to test the ability of the supply system to respond to these demand scenarios. *See p. 79.*

Immigration

- **In 1988, 11,000 scientists and engineers immigrated to the United States.** Almost one-half of these immigrants came from Asia—three times the amount that came from Western Europe. The largest numbers of immigrants came from India, Taiwan, The Philippines, and the United Kingdom, each of which accounted for more than 750 such immigrants. *See p. 83.*

Introduction

Chapter Focus

The 1980s witnessed substantial growth in demand for workers in science and engineering (S&E) activities. New and expanded programs in research and development (R&D), defense, health, and higher education all contributed to this growth. There was also a shift in this decade in the industrial demand composition for S&E personnel, as nonmanufacturing industries began to overtake manufacturing ones as the major employment sector. These changes were generally accomplished through a flexible labor force and an educational system capable of providing the personnel and training required. An increasing use of foreign origin personnel was also a significant factor in meeting the demand, especially at more advanced levels.

The Nation's S&E workforce will face new and different challenges during the nineties. Demand for new S&E workers is expected to increase at a slower pace than that experienced during the 1980s; however, employers will need larger numbers of replacements for attrition from the overall growing S&E labor force.

On the supply side, concerns exist about the impact of a declining college-age population on future levels of new S&E graduates. If the fall in the number of S&E bachelors degrees awarded between 1986 and 1989 continues into the nineties, industry will have to rely more heavily on sources other than new graduates to fill their needs. Employers will need to focus more of their efforts on retaining and retooling their current workforce. These and other factors will together determine the future balance of the S&E labor market.

Chapter Organization

This chapter examines past and projected growth of S&E jobs in the industrial sector, which forms the core of demand for S&E occupations (about two-thirds of total S&E employment). Information on the educational attainment of the science and engineering workforce is also presented. Finally, comparative data on international S&E employment are provided.

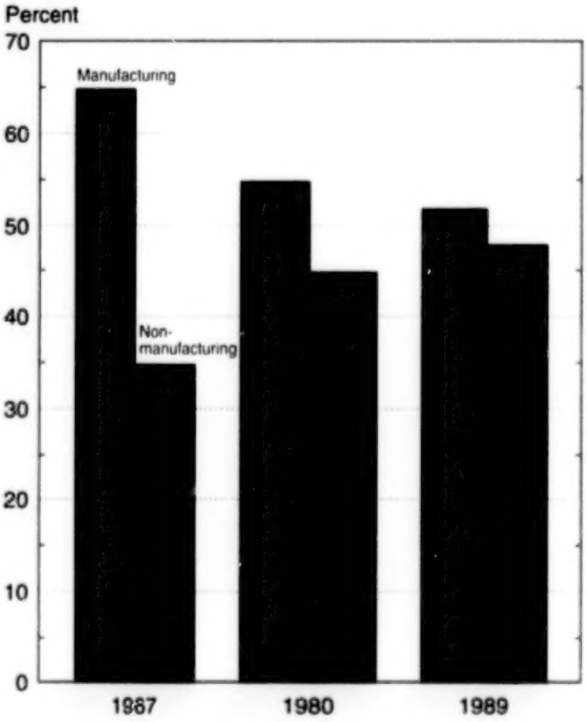
Industrial S&E Job Patterns[1]

In 1989, U.S. private industry provided jobs for nearly 2 million scientists and engineers.[2] This total represented 2.4 percent of all private industry employment, up from 2.1 percent in 1980. Since the 1950s, industrial employment patterns for scientists and engineers have shifted significantly, with strong growth in the 1950-70 period, stagnation and decline in the early and mid-seventies, resurgence in the late seventies through 1980, and generally falling rates of growth since 1981 (SRS 1988a, p. 2).

S&E employment has continued to exceed the growth rate of the total industrial labor force. Between 1980 and 1989, the number of S&E jobs in private industry increased at almost twice the rate for all workers. (See figure O-8 in Overview.) These trends were accompanied by major changes in the industrial sector and occupational mix of S&E employment. Most strikingly, the concentration of industrial S&E employment has gradually shifted from manufacturing to nonmanufacturing since the late 1960s. (See figure 3-1.) This shift reverses the prior trend in relative shares: Between 1950 and 1967, the rate of S&E job growth in manufacturing industries exceeded that in nonmanufacturing. This section delineates other

Figure 3-1.

Distribution of science and engineering jobs in private industry



SOURCES: 1967: Science Resources Studies Division, National Science Foundation, "Services Led in Private Industry Growth in Science/Engineering Jobs," NSF 88-304 (Washington, DC: NSF, 1988); and appendix table 3-1.

Science & Engineering Indicators – 1991

specific growth and occupation trends within these two industrial sectors.[3]

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[1] Analyses in this section are based on data from the Occupational Employment Statistics (OES) Survey conducted annually by the Bureau of Labor Statistics. This large, establishment-based survey collects information on employment in S&E jobs. The individuals holding these jobs need not be formally trained in S&E but rather can have the equivalent of 4 years of training in a related S&E field.

Note that the OES data do not necessarily classify S&E personnel engaged in management as part of the S&E workforce. In the OES Survey, management is a unique occupation; in other surveys referenced in this chapter, management is a permissible S&E job function.

Annual data reported in this section are based on estimates generated by the National Science Foundation. For an explanation of the OES Survey and S&E job estimating methodology, see SRS (1990a), appendix A.

[2] In this section, "private industry" does not include hospitals and other health services, membership organizations, and other nonprofit industries.

Manufacturing Industries

About 200,000 scientists and 800,000 engineers—52 percent of the total industrial S&E labor force—were employed in manufacturing industries in 1989. During the eighties, S&E employment grew in most manufacturing industries at an average annual rate of 3.2 percent. High-tech manufacturing industries, particularly the aerospace industries, accounted for much of the maintenance and increase in the sector's S&E job growth. (See chapter 6, "Performance of New High-Tech Companies," p. 158.) Factors contributing to the generation of high-tech employment included

- Increases in defense spending,
- Greater foreign technological competition,
- Pressure to increase productivity,
- High-technology capital investment, and
- Increased R&D expenditures.

(NSF 1988a, p. 3.)

Growth in S&E Versus Non-S&E Employment. The relative growth rates in employment of S&E and non-S&E personnel in manufacturing industries have varied substantially during the eighties, particularly during the 1981-82 recession. (See figure 3-2.) While total manufacturing employment declined at an average rate of 3.1 percent per year between 1980 and 1983, the number of S&E positions in this sector *rose* by over 3.0 percent per year. Both S&E and total manufacturing employment rebounded—by 4.4 and 0.9 percent, respectively—between 1983 and 1986. The 1986-89 changes were a 2.3-percent average annual increase for S&E positions and, again, less than a 1-percent increase per year for all employees. In 1989, S&E positions represented slightly more than 5 percent of all manufacturing jobs.

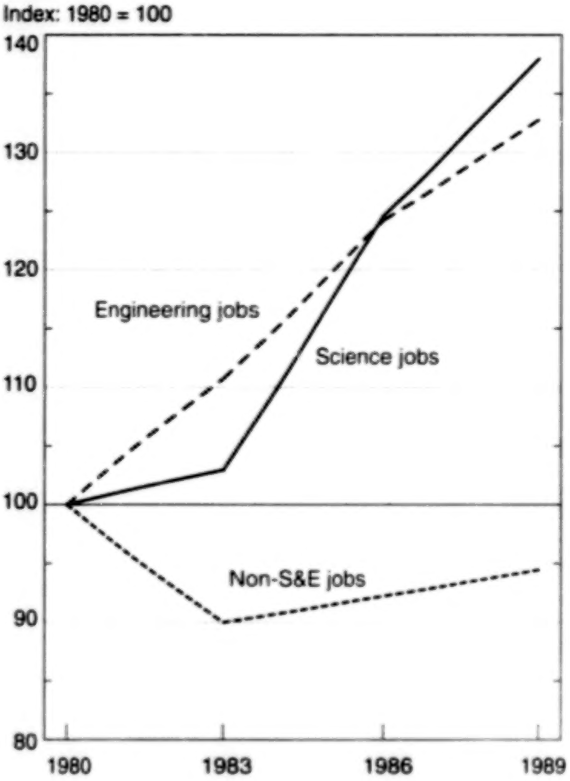
Employing Industries. In 1989, the manufacturing industries employing the largest numbers of scientists and engineers were

- Aerospace, with 183,000 S&E jobs;
- Instruments and related products, 137,000;
- Chemicals and allied products, 113,000; and
- Office and computing equipment, 97,000.

(See figure 3-3.)

The sector's largest S&E employer, the aerospace industry, experienced fairly rigorous growth in its S&E employment throughout the early and mid-1980s, before falling off in the latter part of the decade. Between 1980 and 1983, strong demand for U.S. missiles and military aircraft and consistent levels of space-related activities more than offset dwindling employment in the production of civil aircraft. These factors allowed S&E employment to rise at a rate of 5.3 percent per year. The aerospace industry experienced even more robust S&E job growth in the mid-eighties, with the number of S&E positions increasing by more than 10 percent annually between 1983 and 1986. This growth was buoyed by continued expansion of military orders and the production of large commercial aircraft. More recently, from 1986 to 1989, annual S&E job growth slowed to 2.1 percent, reflecting declining defense budgets in the United States and other developing countries and the attendant reduction in military procurements of aircraft and missile systems (ITA 1990, p. 25-1).

Figure 3-2.
Index of job growth in manufacturing industries



See appendix table 3-1. *Science & Engineering Indicators – 1991*

Nonmanufacturing Industries

The nonmanufacturing sector provided jobs for an estimated 920,000 scientists and engineers in 1989, or 48 percent of total industrial S&E employment. (See appendix table 3-1.) The majority of the sector's S&E employees were engineers—545,000, versus 375,000 scientists. Most of these scientists and engineers were in the service-producing industries; a small proportion were in mining and construction. S&E employment in nonmanufacturing industries increased substantially during the eighties. This increase can be attributed to two main factors:

---

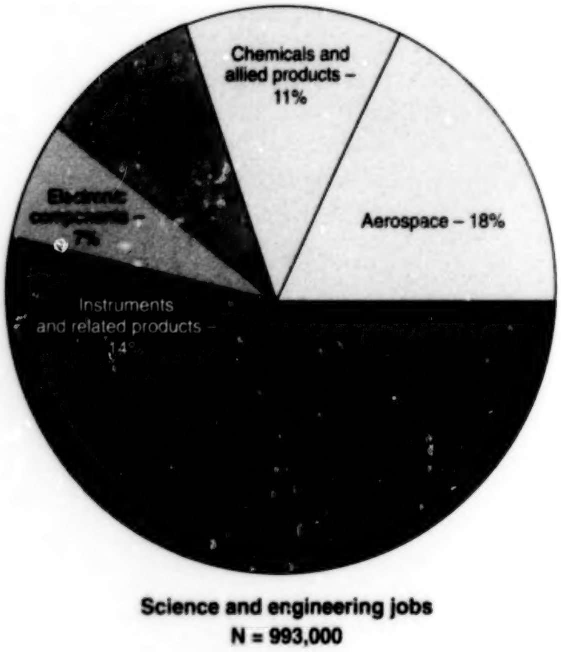
[3] S&E occupational data discussed in this section are limited to Standard Industrial Classification industry groupings.

- A greater share of the total jobs in the nonmanufacturing sector were held by S&E personnel in 1989 versus 1980; and
- The nonmanufacturing sector, unlike the manufacturing sector, experienced general economic growth with attendant increases in overall total employment.

Growth in S&E Versus Non-S&E Employment. Overall, total employment in nonmanufacturing industries grew at an average annual rate of 3.0 percent between 1980 and 1989, while the number of S&E jobs increased on average by 4.5 percent. The proportion of the nonmanufacturing workforce in S&E positions increased during this time from 1.4 percent of total employment to 1.5 percent.

Although S&E job opportunities in nonmanufacturing increased substantially over the decade, growth was not uniform over time. Despite the recession, moderate growth characterized the 1980-83 period—4.5 percent per year on average. Losses of S&E jobs in the mining and construction industries contributed to a lowering of the overall annual rate of S&E job growth in the nonmanufacturing sector to 3.0 percent between 1983 and 1986.

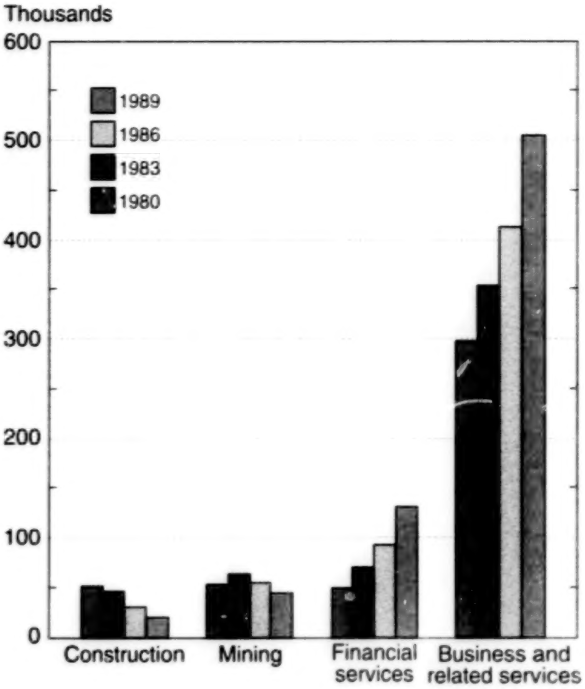
Figure 3-3.
Industry distribution of science and engineering jobs in manufacturing sector: 1989



SOURCES: Bureau of Labor Statistics, Occupational Employment Statistics Surveys; and appendix table 3-1.

Science & Engineering Indicators – 1991

Figure 3-4.
Science and engineering jobs in selected nonmanufacturing industries



See appendix table 3-1. *Science & Engineering Indicators – 1991*

Average annual S&E job growth rebounded to 5.9 percent for the 1986-89 period, primarily because increased S&E job opportunities in the financial services and business and related services industries offset the continuing losses in mining and construction. (See figure 3-4.)

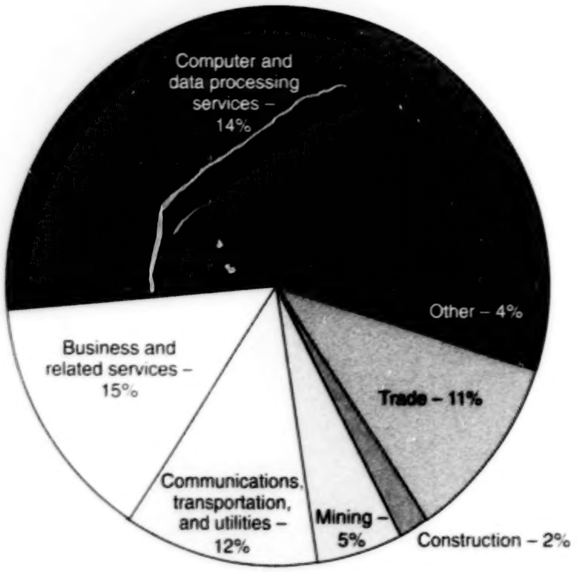
Employing Industries. The major nonmanufacturing industries in terms of S&E employment in 1989 were

- Engineering and architectural services, with 201,000 S&E jobs;
- Business services, 140,000;
- Financial services, 134,000; and
- Computer and data processing services, 125,000.

Together, these industries provided two-thirds of all S&E jobs in the nonmanufacturing sector. (See figure 3-5.) However, two industries are of particular interest, the first—engineering and architectural services—because of its position as the largest provider of S&E jobs in the nonmanufacturing sector and the second—computer and data processing services—because of its phenomenal job growth over the decade.

S&E employment in *engineering and architectural services* increased by more than 60 percent between 1980 and 1989 to over 200,000 personnel. The number of S&E positions in this industry rose at an average annual rate of 5.4 percent over the decade. Most of this growth

Figure 3-5.
Industry distribution of science and engineering jobs in nonmanufacturing sector: 1989



Science and engineering jobs
N = 920,000

SOURCES: Bureau of Labor Statistics, Occupational Employment Statistics Surveys; and appendix table 3-1.

Science & Engineering Indicators – 1991

occurred in the early eighties as a result of strong growth in demand for engineering services by the construction industry.[1]

The extraordinary S&E job growth in *computer and data processing services*—an average 13.1 percent per year between 1980 and 1989—occurred in response to the revolution in information technologies and the strong demand for information services. The industry also includes computer software design, an industry segment that has experienced major growth as new methods of delivering information-related services—e.g., local area networks and electronic data interchange networks—have been developed. Demand for these and related services has resulted in an increase in the number of S&E positions in the computer and data processing services industry from 41,000 in 1980 to 125,000 in 1989.

Occupations

In the eighties, the manufacturing sector remained the primary source of employment for engineers, while scientists continued to find more job opportunities in the nonmanufacturing sector. Nonmanufacturing industries increased their share of total science jobs from 63 to 66 percent during the eighties, while the proportion of engineering jobs in this sector increased from 39 percent to slightly over 40 percent. Conversely, manufacturing industries' share of total science jobs fell from 37 to 34 percent, while the proportion of engineering jobs in this sector increased from 60 to 61 percent. By occupational specialty, however, manufacturing and nonmanufacturing industries showed similar patterns of S&E employment in 1989. (See figure O-9 in Overview.) Employment trends in the largest of these occupational specialties—the computer specialties and electrical/electronic engineering—are described below.

Computer Specialists. The computer specialties dominated science employment growth during the eighties. Between 1980 and 1989, the number of jobs for computer specialists grew almost 7 percent per year, rising to an employment level of 318,000. (See figure O-10 in Overview.) Representing more than half of science employment growth in private industry, job opportunities in this occupation benefitted from the rapid expansion of the computer services industry and the increasingly greater industrial computer use. This increased demand was met by an interdisciplinary supply of workers able to meet job qualifications. Computer specialist jobs could be filled by persons trained in mathematics, engineering, and other S&E fields as well as by those specifically trained in the computer sciences. Nonmanufacturing industries provided more than two-thirds of the job opportunities in this occupation in 1989, primarily in the financial services and computer and data processing services industries.

Electrical/Electronic Engineers. Jobs in electrical/electronic engineering increased at an average rate of more than 5 percent per year between 1980 and 1989. A total 436,000 electrical/electronic engineers in 1989 made this the largest S&E occupational specialty. Manufacturing industries provided approximately three-fifths of the industry jobs in this discipline, largely in the electrical and electronic equipment, transportation equipment, and instruments and related products industries. Among nonmanufacturing industries, business services and engineering and architectural services were the primary source of electrical/electronic engineering jobs.

S&E Jobs in R&D

During the 1980s, R&D employment opportunities increased for industrial scientists and engineers. Two key factors primarily accounted for this increase, which occurred in both manufacturing and nonmanufacturing industries:

- Emerging technology industries (see chapter 6, "Technologies for Future Competitiveness," p. 160) engaged in increasing levels of R&D activity, and
- Competitive pressures propelled U.S. companies to improve and update product designs more rapidly than in the past.

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[1] For example, the services of civil engineers were required for the design and construction of transportation systems, water resource and disposal systems, and environmental control and waste management systems.

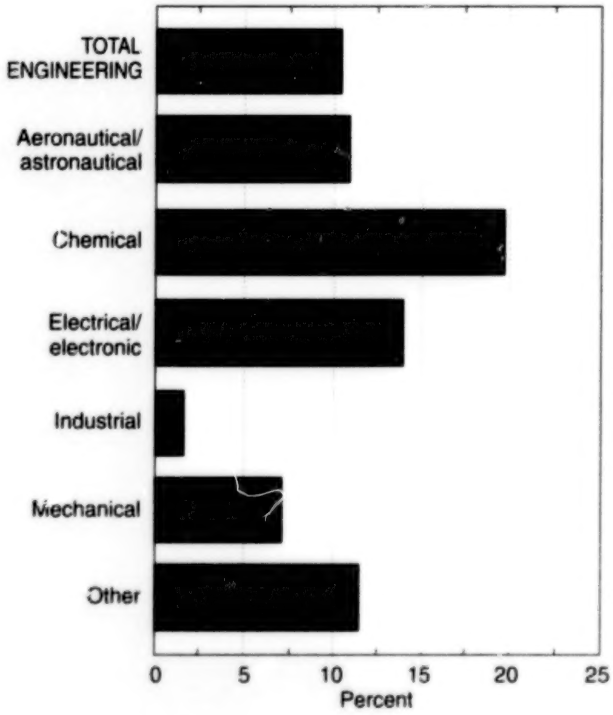
Manufacturing Industries. In 1989 the manufacturing sector provided more than twice as many R&D employment opportunities for engineers as for scientists—78,000 versus 38,000.[5] Of the engineering R&D positions in manufacturing industries, 42 percent (32,000) were in electrical/electronic engineering (including 8,000 jobs in computer engineering). Engineers also found R&D job opportunities in

- Mechanical engineering (9,000),
- Chemical engineering (7,000),
- Aeronautical engineering (6,000), and
- Industrial engineering (2,000).

Almost 22,000 R&D jobs were located in other engineering specialties.

The proportion of engineering jobs in manufacturing that primarily involve R&D work differed greatly by subfield. (See figure 3-6.) In 1989 about 10 percent of the 804,000 total engineering jobs in manufacturing were in R&D. Chemical engineering accounted for the largest proportion of R&D work (19 percent); industrial engineering accounted for the smallest proportion (2 percent).

Figure 3-6.
Engineering jobs in manufacturing that primarily involve R&D, by field: 1989



See appendix table 3-2.

Science & Engineering Indicators – 1991

Four industries provided 80 percent of the engineering R&D jobs in manufacturing in 1989. Transportation equipment employed 25 percent of the R&D engineers; nonelectrical machinery, 21 percent; electrical machinery, 18 percent; and instruments, 17 percent. These four industries also employed about 80 percent of the 726,000 non-R&D engineers, in almost the same proportions as of R&D engineers.

Three occupational groups accounted for almost all of the manufacturing R&D jobs for scientists:

- Physical scientists (56 percent),
- Life scientists (30 percent), and
- Computer specialists (12 percent).

Over 90 percent of the 12,000 R&D jobs for life scientists were in chemicals and allied products industries, as were 76 percent of the 21,000 R&D jobs for physical scientists.

Nonmanufacturing Industries. In the nonmanufacturing sector in 1987, R&D job opportunities were slightly higher for engineers (40,000) than for scientists (34,000).[6] Practically all R&D positions (97 percent) were located in business and related services.

Unlike the manufacturing sector, the R&D jobs for scientists in this sector were distributed across all the major occupational groups, as follows:

- Physical scientists, 10,000 jobs;
- Computer specialists, 10,000;
- Life scientists, 8,000;
- Mathematical scientists, 3,000; and
- Social scientists, 3,000.

(See figure 3-7.)

Approximately 90 percent of the R&D jobs for physical scientists and 70 percent of those for computer specialists were in the business services industry (primarily computer and data processing services and commercial R&D labs). R&D jobs for life scientists were divided between business services (53 percent) and miscellaneous services (47 percent).

About half (21,000) of the engineering R&D jobs in the nonmanufacturing sector were in electrical/electronic engineering. The remaining R&D jobs were distributed as follows:

- Mechanical engineering, 7,000 jobs;
- Aeronautical engineering, 1,000;
- Civil engineering, 1,000; and
- Industrial engineering, 1,000.

Almost 9,000 R&D jobs were located in other engineering specialties.

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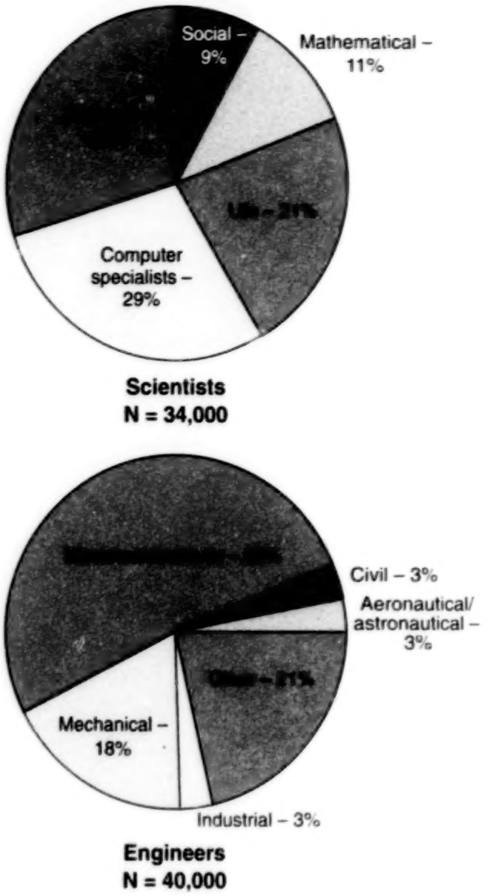
[5] As used here, R&D scientists and engineers refer to those who "spend the greater part of their work time on research and development."

[6] This is the latest year for which data are available; numbers are rounded to the nearest thousand.

Figure 3-7.
Distribution of science and engineering R&D jobs in nonmanufacturing, by occupation: 1987



Scientists
N = 34,000

Engineers
N = 40,000

SOURCE: Bureau of Labor Statistics, Occupational Employment Statistics Surveys.

Science & Engineering Indicators – 1991

Approximately two-thirds of the engineering R&D jobs in the nonmanufacturing sector in 1987 were located in business services, with miscellaneous services providing the remaining one-third of the R&D jobs. This distribution was uniform across most engineering occupations, with the exception of mechanical engineering. Approximately 80 percent of these R&D jobs were located in the business services industry.

Demographic Trends: Recent S&E Graduates

Recent S&E graduates form a key component of the Nation's science and engineering workforce; they account for almost half of the annual inflow into the S&E labor market (SRS 1990a, p. 40). The career choices of recent graduates and their entry into the labor market affect the balance between the supply of and the demand for scientists and engineers in the United States. (See "Supply and Demand Outlook for S&E Personnel," pp. 79-83.) Analysis of the workforce status and other characteristics of recent S&E graduates can yield valuable labor market information.[7] These data have been used by government policymakers to determine the levels of support for education or other governmental programs, by employers as an input to staffing decisions, by educators to forecast enrollment patterns, and by students in making career choices.

This section provides several labor market measures that offer useful insights into the overall supply and demand conditions for recent S&E graduates in the United States. Among these measures are median annual salaries, unemployment rates, S&E employment rates, and in-field employment rates.

Market Conditions

Upon graduation, new S&E bachelors and masters degree recipients must choose whether to enter the job market or continue their education. In 1990, three-quarters of these recent S&E degree recipients were employed on a full-time basis. The majority were employed in S&E occupations: More masters recipients than bachelors recipients were reported as so employed. A very low number of recent S&E graduates (3 percent of bachelors and 2 percent of masters degree graduates) were unemployed and actively looking for jobs. (See figure 3-8.) Of those recipients of S&E degrees who were not in the labor force 1 or 2 years after graduation, most (20 percent of bachelors graduates and 22 percent of masters graduates) were full-time graduate students.

Median Annual Salaries[8]

Median annual salaries of recent S&E graduates serve as an excellent indicator of the relative demand for new workers in various S&E fields. The median annual salary reported by recent S&E baccalaureate recipients was $26,000 in 1990; at the S&E masters degree level, the median salary reported was $37,000. (See text table 3-1.) Historically, the annual salaries of recent engineering degree recipients have been higher than those of graduates with science degrees. Accordingly, in 1990, baccalaureate engineering degree recipients reported a median annual salary of $33,000; their science counterparts reported a median annual salary of $23,000. Among masters degree recipients, the median salaries were $41,400 and $33,800 for engineering and science, respectively.

By Field. Among science fields, there was considerable variation in median salaries. Recipients of bachelors and masters degrees in the computer sciences had much

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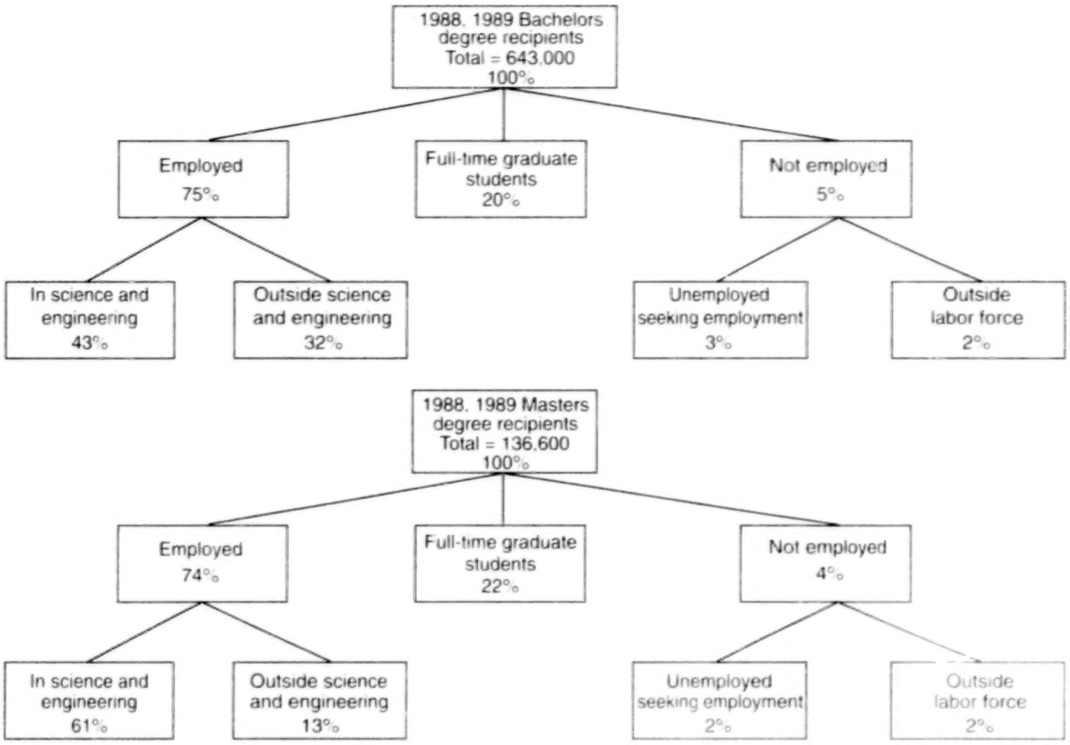
[7] Data for this section are from the 1990 Survey of Recent Science, Social Science, and Engineering Graduates. This survey collected information on the 1990 workforce/other status of 1988 and 1989 bachelors and masters degree recipients in S&E fields. Surveys of recent S&E graduates have been conducted biennially for the National Science Foundation by the Institute for Survey Research, Temple University. For information on standard errors associated with survey data, see SRS (forthcoming).

[8] Median annual salary is that of full-time employed civilians rounded to the nearest $100.

Figure 3-8.

Transition of recent science and engineering degree recipients: 1990


1988, 1989 Bachelors degree recipients
Total = 643,000
100%
Employed 75%
Full-time graduate students 20%
Not employed 5%
In science and engineering 43%
Outside science and engineering 32%
Unemployed seeking employment 3%
Outside labor force 2%
1988, 1989 Masters degree recipients
Total = 136,600
100%
Employed 74%
Full-time graduate students 22%
Not employed 4%
In science and engineering 61%
Outside science and engineering 13%
Unemployed seeking employment 2%
Outside labor force 2%

See appendix tables 3-3, 3-4, 3-7, 3-10, and 3-11.

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larger median annual salaries than did other science degree recipients. The next highest median salaries were reported by recipients of degrees in the physical sciences. The lowest median annual salary at the baccalaureate level was reported by recipients of psychology degrees; the lowest such salary at the masters level was received by recipients of life science degrees.

With the exception of civil engineering, median annual salaries among engineering subfields were fairly uniform at both the bachelors and masters degree levels. Median annual salaries reported by civil engineering degree recipients were significantly lower than for other engineering subfields at both the bachelors and masters degree levels.

Growth in Salaries. During the eighties, median annual salaries rose at an average annual rate of 5.4 percent for bachelors degree recipients and 5.9 percent for masters degree recipients. Salary growth was not uniform throughout the decade, however. (See figure 3-9.) Between 1986 and 1990, median salaries for bachelors degree recipients increased at an average annual rate of less than 1.0 percent, while median annual salaries for masters degree recipients rose at an average rate of 3.3 percent annually.

Text table 3-1.

Median annual salaries of recent science and engineering graduates, by degree level and field: 1990

Field	Bachelors	Masters
Total science and engineering	$26,000	$37,000
Total sciences	23,000	33,800
Physical sciences	25,100	34,900
Mathematical sciences/statistics	23,600	32,800
Computer sciences	30,100	42,100
Environmental sciences	23,700	33,800
Life sciences	21,000	26,900
Psychology	18,600	32,000
Social sciences	21,900	31,000
Total engineering	33,000	41,400
Aeronautical/astronautical	34,800	46,500
Chemical	35,100	40,200
Civil	30,100	35,200
Electrical/electronic	34,000	46,500
Mechanical	34,000	42,100

See appendix tables 3-5 and 3-6

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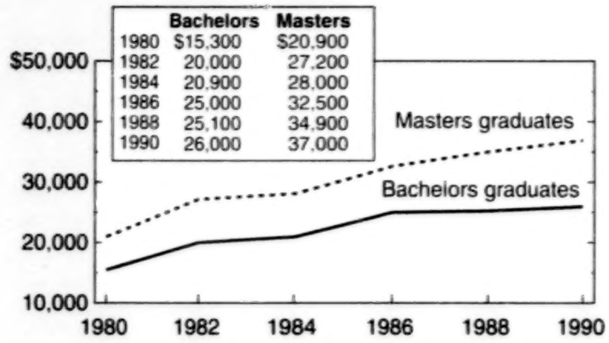
Figure 3-9.
Median annual salaries of recent science and engineering graduates



	Bachelors	Masters
1980	$15,300	$20,900
1982	20,000	27,200
1984	20,900	28,000
1986	25,000	32,500
1988	25,100	34,900
1990	26,000	37,000

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1991

Salaries for Women and Minorities. In 1990, the median annual salaries of recent female baccalaureate recipients employed as scientists and engineers were approximately 73 percent of the salaries of their male counterparts. Much of this difference is due to the concentration of women in relatively low-paying S&E fields such as psychology and the life sciences (SRS 1990b).

By racial/ethnic group, new Asian baccalaureate recipients reported a median annual salary of $30,000 in 1990; this was almost 15 percent higher than the salary reported by whites ($26,100). Hispanics ($25,100), blacks ($24,000), and Native Americans ($21,900) all reported median salaries below that of whites. At the masters degree level, the median salary for Asians ($35,900) was approximately the same as for other minority groups, although less than for whites ($37,500).

Unemployment Rates

A standard measure of labor market conditions is the unemployment rate, which measures the proportion of those in the workforce who are not employed but are seeking work. A high unemployment rate may indicate that the supply of S&E graduates is more than sufficient to meet market demands. A low unemployment rate, on the other hand, may indicate that the demand for graduates exceeds their supply in the marketplace.

In 1990, the unemployment rate reported by recent S&E graduates was 3.4 percent among baccalaureate degree recipients and 1.8 percent for masters degree recipients. By comparison, the overall unemployment rate in the United States was 5.5 percent in 1990 and 1.9 percent for professional workers (BLS 1991, p. 174). The unemployment rates for recent S&E graduates in 1990 were higher than comparable rates reported in 1988.

S&E Employment Rates

The S&E employment rate measures the extent to which employed scientists and engineers have S&E jobs. Reasons for non-S&E employment include lack of available S&E jobs, higher pay for non-S&E employment, location, or preference for a job outside of S&E.

In 1990, approximately 62 percent of recent S&E bachelors degree recipients and 89 percent of recent S&E masters degree recipients were employed in science and engineering jobs. S&E employment rates for recent bachelors degree recipients were lower than those for masters degree recipients across almost all fields, although there was considerable variation in rates by field.

In the sciences, 28 percent of social science and 30 percent of psychology baccalaureate recipients worked in jobs related to science or engineering. In contrast, almost 88 percent of the people holding computer science bachelors degrees and 85 percent of those with physical science and environmental science degrees were employed in S&E jobs. Engineering rates did not vary as much by subfield. With some minor exceptions, more than 90 percent of *all* engineering degree graduates—both at the bachelors and masters degree levels—were employed in S&E jobs in 1990. Bachelors degree-holders in aeronautical/astronautical engineering (82 percent) and bachelors and masters degree-holders in industrial engineering (85 percent and 79 percent, respectively) were the exceptions to this.

In-Field Employment Rates

Many recent S&E graduates find jobs directly related to their degree fields, although it is more common for masters degree recipients than for bachelors degree recipients to do so. In 1990, 59 percent of masters degree recipients and 38 percent of bachelors degree recipients were employed in fields directly related to their degrees. (See text table 3-2.) Regardless of degree level, the highest in-field employment rates were reported by recipients of computer science, civil engineering, and environmental science degrees.

At the bachelors degree level, in-field employment rates ranged widely from 10 percent for psychology to 82 percent for computer science. Among masters degree recipients, the range was much narrower, with 44 percent of social science graduates and over 77 percent of computer science graduates employed in jobs associated with their degree fields.

Primary Work Activities

The work activities of recent S&E graduates varied by degree level in 1990. (See figure 3-10.). Bachelors degree recipients were more likely than masters degree recipients to be employed in jobs oriented toward production and inspection, sales and professional services, or general management. Masters degree recipients were

Text table 3-2.
In-field employment rates of recent science and engineering graduates, by degree and field: 1990

Field	Bachelors	Masters
Total science and engineering	37.8	59.0
Total sciences	33.2	59.6
Physical sciences	35.6	43.4
Mathematical sciences/statistics	39.6	57.4
Computer sciences	81.5	77.2
Environmental sciences	56.1	69.4
Life sciences	38.4	59.0
Psychology	9.9	48.1
Social sciences	14.1	43.5
Total engineering	50.7	57.8
Aeronautical/astronautical	48.9	*
Chemical	49.6	*
Civil	71.1	69.1
Electrical/electronic	53.3	57.7
Mechanical	44.3	60.4

* = too few cases to report

See appendix table 3-7. *Science & Engineering Indicators – 1991*

more concentrated in jobs focusing on R&D, R&D management, and teaching.

The primary work activities of recent S&E graduates varied substantially by field. At both degree levels in 1990, engineering graduates were more likely to be employed in R&D and production and inspection; science degree recipients were more likely to be employed in general management, teaching, or a combination of activities related to reporting, statistical work, and computing.

Sectors of Employment

Industry was the primary employer of new S&E graduates in 1990, providing jobs for 65 percent of recent bachelors degree recipients and 60 percent of recent masters degree recipients. Educational institutions employed 10 percent of bachelors degree-holders and 17 percent of those with masters degrees. Only 4 percent of recent baccalaureate and 8 percent of masters degree recipients were employed by the Federal Government in 1990.

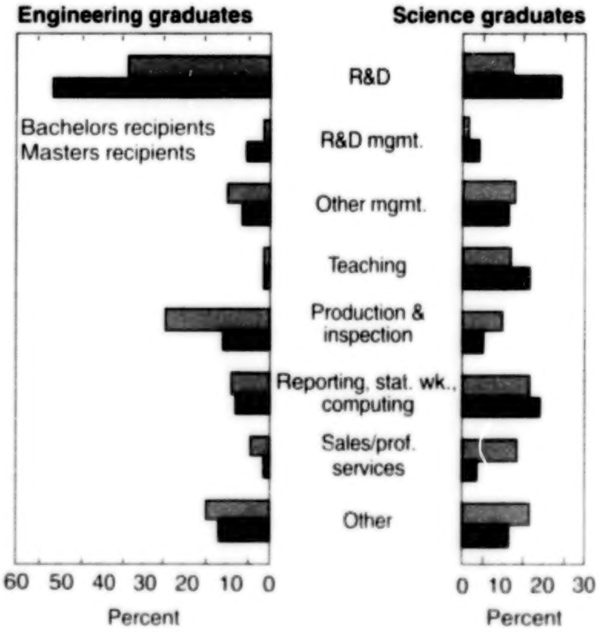
The employment distribution of recent S&E graduates by sector did not change markedly over the 1980-90 period. However, there were some sectoral shifts by field of degree—specifically, by engineering degree recipients. The percentage of recent graduates with bachelors degrees in engineering employed by the Federal Government increased from 4 percent in 1980 to 6 percent in 1990.[9] However, the Federal share of recent masters degree recipients in this field declined from 9 to 7 percent over the period. State and local governments similarly increased their share of recent bachelors degree recipients in engineering from 3 percent in 1980 to 5 percent in 1990 and decreased their share of masters degree graduates in engineering from 4 to 3 percent. These fluctuations in S&E employment can be attributed to shifts in defense spending over the decade.

Industry has accounted for the largest share of recent S&E graduate employment. The share of recent graduates with masters degrees in engineering employed by industry has increased from 76 percent in 1980 to 78 percent in 1990. Conversely, over the same period, baccalaureate engineering recipients have declined in their share of industrial employment, dropping from 88 to 78 percent. For science degree recipients, industry's share of recent graduates with masters degrees increased from 40 to 51 percent between 1980 and 1990, while its share of recent bachelors degree recipients rose from 58 to 60 percent.

Demographic Trends: Doctorate Recipients[10]

In 1989, the population of doctoral scientists and engineers was about 485,000, an increase of 4 percent per year since 1977 when it was almost 304,000. The annual

Figure 3-10.
Distribution of bachelors and masters science and engineering graduates, by primary work activity: 1990



See appendix tables 3-8 and 3-9.

Science & Engineering Indicators – 1991

rate of retirement for doctoral scientists and engineers increased from about 0.5 percent between 1977 and 1979 to 0.8 percent during the 1987-89 period.[11] The effect of this change was a dramatic increase in the proportion of the doctoral scientist and engineer population who were retired—a rise from 3.2 percent in 1977 to 5.6 percent in 1989. Most of this increase occurred after 1985, when retirees accounted for 3.5 percent of the S&E doctoral population. As larger proportions of doctoral S&E workers enter the 55 years and older age group, retirements may begin to have a significant impact on their supply.

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[9] Data for 1980 are from SRS (1982).

[10] Data for this section are from the National Science Foundation's Survey of Doctorate Recipients biennial survey series. The most recent survey was conducted in 1989. For information on standard errors associated with these survey data, see SRS (1991).

Retirees varied considerably by degree field. In 1989, retirees accounted for between 6.5 and 8.5 percent of the doctorate-holders in the physical and social sciences and in chemical engineering. Rates were much lower—3.5 to 5.1 percent—among doctorate-holders in the mathematical and environmental sciences, psychology, and electrical and mechanical engineering. No retirements were reported by individuals in the computer sciences, a relatively new field.

Market Conditions

The likelihood of scientists and engineers at the doctorate level to enter the workforce remained very high in 1989 and appeared to have been unaffected by swings in the Nation's economy during the late seventies and eighties. Throughout the 1977-89 period, the labor force participation rate of doctoral scientists and engineers was approximately 95 percent. Doctoral scientists and engineers had little trouble finding work during this period; their reported unemployment rate ranged from 1.2 percent in 1977 to less than 1 percent in 1989 (SRS 1991). By contrast, the overall unemployment rate in the United States was 5.3 percent in 1989 and 1.7 percent for professional workers (BLS 1991). The unemployment rate for scientists and engineers at all degree levels combined was 1.5 percent in 1988 (SRS 1990c).

Employment Rates

Employment of doctoral scientists and engineers reached 449,000 in 1989, an increase of 57 percent (3.9 percent per year) over 1977. Since 1983, however, employment growth of S&E doctorate-holders has slowed. The annual rate of increase for the 1983-89 period was 3.3 percent per year, compared to 4.4 percent annually between 1977 and 1983.

Despite substantial variation within individual S&E fields, the overall proportions of employed doctoral scientists (83 percent) and engineers (17 percent) have remained constant since 1977. The higher proportion of science doctorate-holders reflects (1) their relative concentration in academia and (2) the higher level of education needed by scientists (compared to engineers) for professional status.

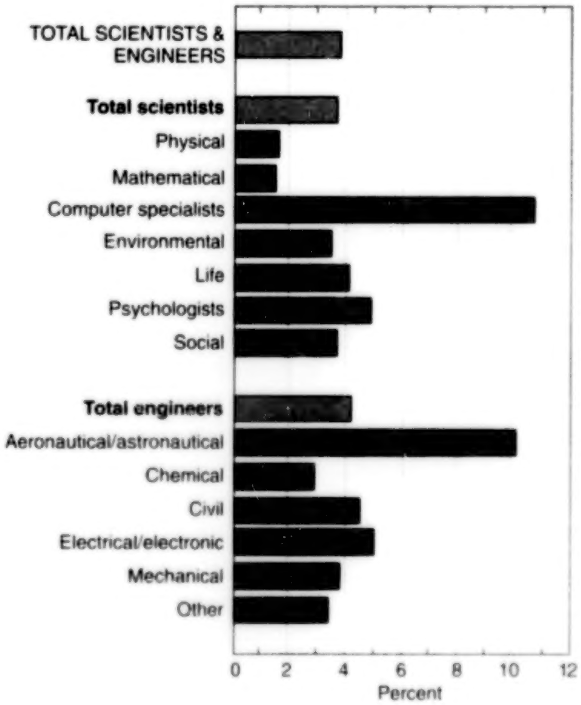
Within both science and engineering, growth rates for employed doctoral scientists and engineers varied considerably by field over the 1977-89 period. (See figure 3-11.) Among the sciences, where overall growth was approximately 4 percent per year, the lowest rate was in the mathematical sciences (1.6 percent per year). With almost 11-percent annual growth, the computer specialties was the fastest growing field. Growth among the engineering subfields varied within a narrower range. Overall employment of doctoral engineers also increased at an annual rate of slightly over 4 percent; by subfield, growth ranged from 3.0 percent per year for chemical engineers to almost 10 percent per year for aeronautical/astronautical engineers.

These differing growth rates altered the field distributions of the S&E doctoral workforce over the 1977-89 period. Among scientists, the proportions employed as computer specialists, psychologists, and life scientists increased while the percentages employed as physical, mathematical and social scientists declined. In contrast, there were relatively modest shifts among engineering subfields. (See figure 3-12.)

Primary Work Activities

Between 1977 and 1989, the number of doctoral scientists working primarily in R&D increased by about 60 percent, while the number of their engineering counterparts rose 74 percent. Approximately 33 percent of

Figure 3-11.
Annual rates of employment growth for doctoral scientists and engineers, by field: 1977-89



See appendix table 3-12. *Science & Engineering Indicators – 1991*

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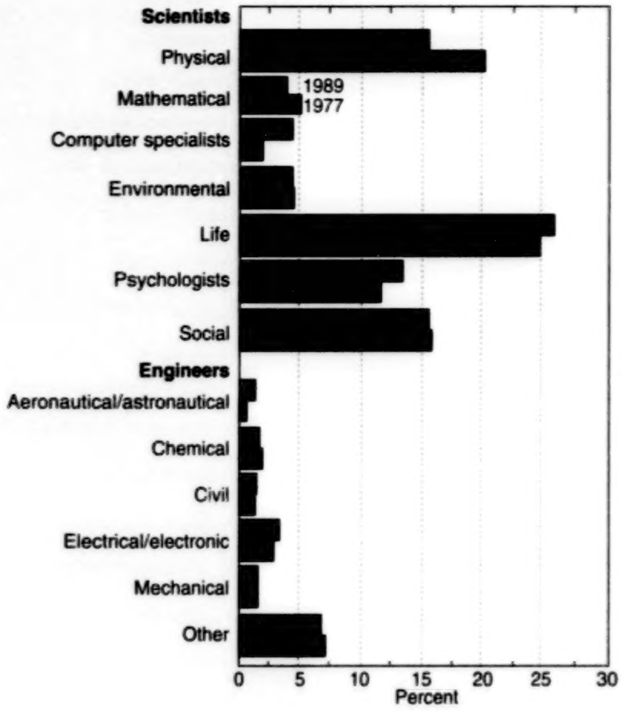
[11] The retirement rate is the number of individuals who retired during a 2-year interval divided by the total population at the beginning of the interval—e.g., the number of individuals who retired between 1987 and 1989 expressed as a percentage of the 1987 population.

Figure 3-12.
Distribution of employed doctoral scientists and engineers, by field



See appendix table 3-12. *Science & Engineering Indicators – 1991*

Ph.D.-holding scientists and 30 percent of doctoral engineers reported basic or applied research as their primary work activity in 1989, up from 29 and 23 percent, respectively, in 1977. (See figure 3-13.) Another 3 percent of doctoral scientists and 16 percent of doctoral engineers were working in development in 1989.

The next most prevalent work activity was teaching. Approximately 27 percent of doctoral scientists and 17 percent of doctoral engineers reported teaching as their primary work activity in 1989. In 1977, these proportions were higher—34 and 20 percent, respectively; the downward trend reflects the shift in Ph.D. concentration from academia to industry.

About 7 percent of doctoral scientists and 15 percent of doctoral engineers cited R&D management as their primary work activity in 1989. These proportions were down from 9 and 19 percent, respectively, in 1977.

Sectors of Employment

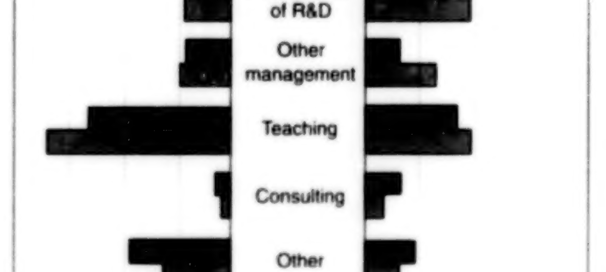
Although educational institutions remained the primary employer of S&E doctorate-holders in 1989, this sector's employment share has declined steadily since the late 1970s. Industry's share of doctoral scientists and engineers meanwhile has increased. In 1977, 62 percent of Ph.D.-holding scientists and 35 percent of their engineering counterparts were employed in academia; by 1989, the proportion of scientists had dropped to 55 percent and that of engineers to under 34 percent. (See figure O-11 in Overview.) Concurrently, the proportion of doctoral scientists employed in industry increased from 20 to 28 percent, and that of engineers from 51 to 56 percent. The following paragraphs further detail this shift from academia to industry.

Educational Institutions. Between 1977 and 1989, doctoral S&E employment in educational institutions increased at an average rate of 2.9 percent per year; this was about half the 6.1-percent rate for industry. As a result of academia's slower growth, the proportion of the Nation's Ph.D.-holding scientists and engineers employed in this sector declined from 57 to 51 percent.

The relative importance of academia as a source of employment for S&E doctorate-holders varied considerably by field. Roughly three-fifths of all doctoral scientists were employed in this sector, compared to about one-third of all doctoral engineers. Educational institutions employed 71 percent of the Nation's social science doctorate-holders, 61 percent of the Ph.D.-holding life scientists, and 44 percent of doctoral psychologists.

Growth in academic doctoral employment also varied by S&E field over the 1977-89 period. (See figure 3-14.) Doctorate-holding computer specialists increased at the fastest rate—an average annual rate of almost 10 percent. Life scientists and engineers in all subfields registered above average growth rates—3.5 percent and

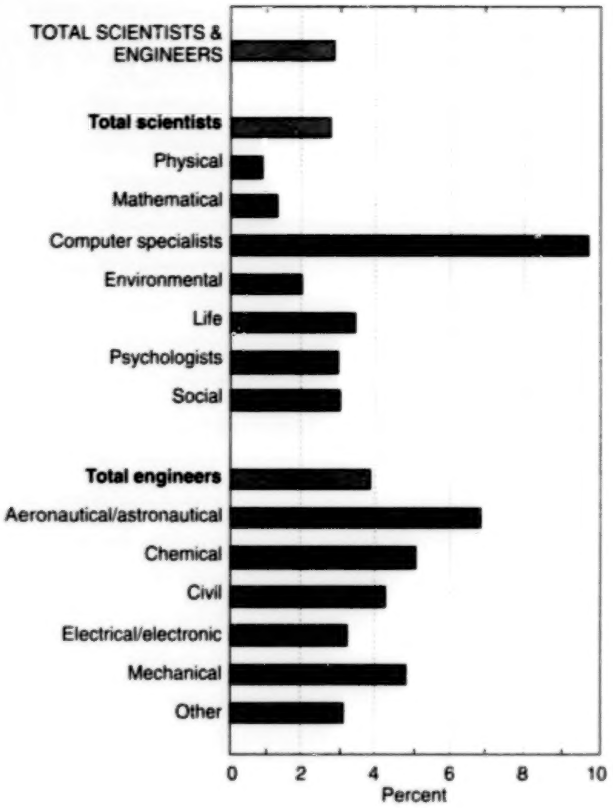
Figure 3-13.
Distribution of employed doctoral scientists and engineers, by primary work activity



See appendix table 3-14. *Science & Engineering Indicators – 1991*

Figure 3-14.

Annual rates of growth for doctoral scientists and engineers in academia: 1977-89



See appendix table 3-15. *Science & Engineering Indicators – 1991*

almost 4 percent annually. Slower than average growth was recorded by physical and mathematical scientists, who increased by only 0.9 and 1.3 percent per year, respectively. These differing growth rates changed the field distribution of doctoral scientists and engineers over the period. For example, the proportion of physical scientists declined from about 17 to 13 percent, and the proportion of engineers rose from 10 to 11 percent.

After experiencing a slowdown in growth in the mid-eighties, doctoral scientist employment in academia has rebounded in recent years. Employment of Ph.D.-holding scientists increased at an average annual rate of 2.7 percent between 1987 and 1989, up substantially from an annual growth of 1.3 percent for the previous 2-year period. Opposite patterns were experienced by doctoral engineers, whose employment increased by 4.5 percent annually over the 1985-87 period and then dropped to less than 3 percent per year over the next 2-year period.

Industry. Since the late seventies, the sectoral distribution of doctoral scientists and engineers has shifted toward industry, increasing at average annual rates of 6.5 and 5.2 percent, respectively. By 1989, 28 percent of all Ph.D.-holding scientists and 56 percent of all doctoral engineers worked in industry. The computer sciences, psychology, and the social sciences were the fastest growing science fields for doctorate-holders employed in industry; aeronautical/astronautical, civil, and electrical/electronic were the fastest growing engineering subfields.

Overall, industrial employment of S&E doctorate-holders has slowed since the early eighties. Between 1983 and 1989, the employment of doctoral scientists in industry increased at an average rate of 4.6 percent annually; doctoral engineering employment rose 3.3 percent per year. These declining growth rates reflect several factors, including

- A greater demand by academia for S&E doctorate-holders;
- A shortage of doctoral personnel in such high-demand S&E fields as the computer sciences and certain engineering specialties; and
- The relatively strong growth in development activities, which, as compared to basic and applied research, are generally carried out by less highly trained personnel (SRS 1988b, p. 22).

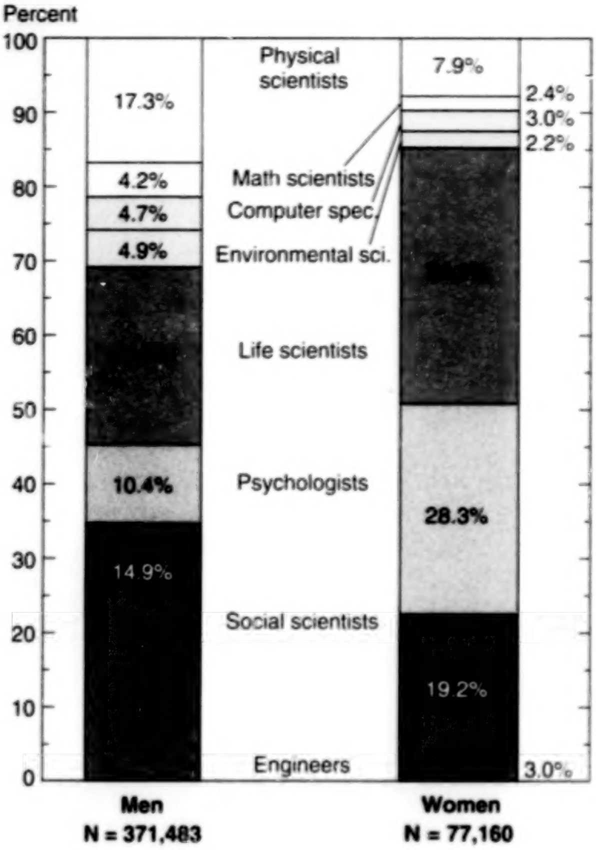
A few S&E fields/subfields did not experience a declining growth rate in the latter half of the 1977-89 period: These were the physical sciences and mechanical and civil engineering.

Employment of Women and Minorities

Women. Women continue to account for an increasing share of the employed Ph.D.-holding scientists and engineers. Their representation grew to 17.2 percent in 1989 compared to 9.7 percent in 1977. The fields with the greatest relative growth of women doctorate-holders were the computer sciences—which increased employment of doctoral women from fewer than 250 in 1977 to over 2,300 in 1989—and engineering—which increased employment from fewer than 300 to over 2,300 during the same period. Despite this rapid growth, only about 6 percent of doctoral women were either computer specialists or engineers in 1989. (See figure 3-15.) The life sciences, social sciences, and psychology together accounted for over 80 percent of the period's increase in the employment of doctoral women. Overall, the field distribution of women with science doctorates did not change greatly over the 1977-89 period. Women were, however, somewhat more likely to be psychologists or computer specialists and less likely to be mathematical or physical scientists in 1989 than in 1977.

Minorities. During 1977-89, the numbers of employed black and Asian S&E doctorate-holders rose at average annual rates of 8.4 and 8.0 percent, respectively. (See figure 3-16.) These rates were over twice the 3.7-percent rate for whites. Recently (1987-89), S&E doctorate growth has slowed; black and Asian Ph.D.-holders increased at average rates of 6.1 and 6.3 percent per year, respectively; the corresponding rate for whites was 3.2 percent.

Figure 3-15.
Distribution of employed doctoral scientists and engineers, by field and gender: 1989



See appendix table 3-12. *Science & Engineering Indicators – 1991*

Despite their rapid employment growth, blacks accounted for only about 1.6 percent (7,200) of all employed doctoral scientists and engineers in 1989. This proportion represented a slight increase over 1977, when blacks accounted for only 1.0 percent of employed doctoral scientists and engineers. On the other hand, the more than 41,000 employed Asians with S&E Ph.D. degrees represented about 9.2 percent of the total in 1989, up significantly from 5.7 percent in 1977.

Supply and Demand Outlook for S&E Personnel[12]

The 1990s should be a period of relative stability in S&E labor markets, particularly as compared with the defense buildup of the early to mid-1980s when many S&E fields experienced temporary shortages.[13] This conclusion has been reached after a careful examination of

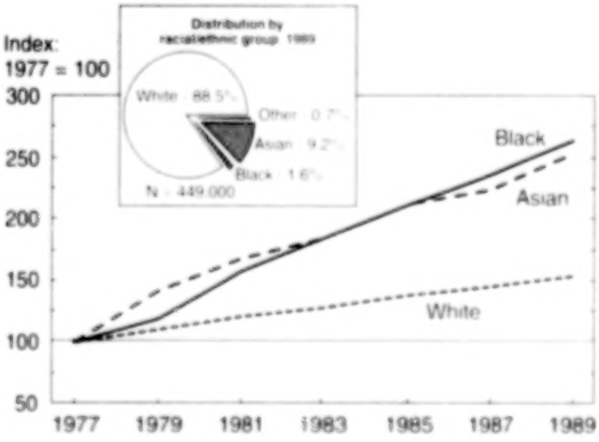
- Various demand simulations to determine how alternative national economic growth patterns might affect S&E employment, and
- Supply side simulations to test the ability of the supply system to respond to these various demand scenarios.

The supply and demand models used to produce these simulations try systematically to account for the many institutional features, individual behavior patterns, demographic trends, and economic forces that govern S&E labor markets (Leslie and Oaxaca 1991). Results and features of these models are provided in this section.

Operations of the S&E Labor Market

Because the performance of the U.S. economy is a major influence on S&E employment, it is important to understand the fundamental operations of the economy in generating jobs for scientists and engineers (see "S&E Employment: Demand Side," p. 80), and in filling those jobs through education and training institutions (see "S&E Employment: Supply Side," p. 81). The models upon which the following results are based attempt to

Figure 3-16.
Index of doctoral science and engineering employment, by racial/ethnic group



See appendix table 3-13. *Science & Engineering Indicators – 1991*

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[12] The model presented here represents one of several possible approaches to examining the outlook for S&E personnel. Equally robust models with different assumptions about demographic trends, or incorporating different personnel populations, job mobility, and other factors are likely to yield different results. Employment projections for the study were generated by NSF's PC occupations modeling system, developed by Data Resources, Inc./McGraw-Hill. The supply projections were based on a model that incorporates all major sources of response to changes in demand. Developed under grant to Dr. Robert Dauffenbach (Oklahoma University), these projections are intended to identify potential problems within the S&E labor market, as well as to assist in understanding the dynamics and flexibility of the S&E labor supply.

[13] The term "relative stability" indicates an overall balance between total supply and demand for scientists and engineers. It does not mean that supply and demand for each S&E field will be in perfect equilibrium throughout the decade. As has been the case in the past, spot shortages and surpluses will continue to occur across various S&E fields in response to supply/demand fluctuations.

S&E Employment: Demand Side

From the demand perspective, employment of S&E personnel begins with "final industry demand"—that is, the output of goods and services from the various agriculture, mining, manufacturing, and service industries that is available for purchase by households, businesses, government, and foreigners. Because industries buy raw materials, products in intermediate stages of production, and services from other industries, the total volume of production in a given industry exceeds the total available for final purchase. *Final demand* in the various industries thus needs to be translated into *total output* per industry.

Once total industry output is known, productivity ratios—that is, output divided by labor input—can be used to compute employment by industry. From there, it is a simple matter to translate the industrial employment into occupational employment. This translation is accomplished through use of the occupational employment distribution per industry—the percentage of employees who are scientists and engineers, managers, clerical employees, blue-collar, etc. Summing the resulting employment by occupation across industries yields total occupational demand. Thus, through such models, it is possible to translate alternative final demand patterns into estimates of total employment by occupation.

capture these fundamental operations systematically. In this manner, alternative scenarios about the future and the ability of the supply system to meet such contingencies can be examined and assessed.

A variety of demand scenarios can be envisioned. For example, one scenario might involve high overall growth in U.S. output, a shift toward services and away from manufactured goods, lower military hardware production, and extensive defense and nondefense R&D. It is possible to imagine other scenarios that might involve slow overall growth of the U.S. economy, but with a shift in production of goods and services toward industries that rely heavily on S&E employment. Even though aggregate economic output would not change under such a scenario, S&E employment would expand. Many such scenarios could be developed and then tested relative to the ability of the supply system to respond.

Three adjustment mechanisms dominate supply responses in the present modeling framework: degree shares, employment retentions, and field mobility. In response to high levels of demand, degree shares (S&E degrees as a percentage of total degrees awarded) increase in the corresponding categories (Dauffenbach 1990). Also, retentions in S&E employment domains increase, which is to say that a high percentage of S&E graduates remain in S&E occupations rather than pursue alternative careers in marketing and management. In addition, workers with training in the shortage occupations become more concentrated in their respective fields of employment, and workers with training in related fields shift their employment to the occupations experiencing shortfalls. Final outcomes of the supply simulations show the leveling effects of the operations of the supply system. Both shortages and surpluses are lessened, exhibiting much more favorable balance than the initial changes in demand would indicate.

Projected Demand for S&E Personnel

As described above, projections are forecasts that are conditional upon a variety of assumptions that depict economic, institutional, and social conditions. The analysis in this section was therefore designed not to provide a single numeric estimate of future employment requirements, but instead to provide a well-defined range within which employment growth is likely to occur during the 1990-2000 period.

Three projection scenarios—a "low," a "mid," and a "high"—were analyzed with the demand model using alternative sets of assumptions designed to encompass likely economic performance during the simulation period 1990-2000.[14] (See text table 3-3 for a summary of these

Text table 3-3.
Summary statistics for macroeconomic scenarios: 1990-2000

Indicator	Macroeconomic scenarios Low	 Mid	 High
	Average annual real growth		
	Percent		
GNP	1.7	2.2	2.7
Consumption	1.4	1.7	2.1
Business fixed investment	2.2	3.6	5.1
Exports	5.2	5.7	6.1
Imports	3.7	4.0	4.8
	Average annual growth		
Labor force	0.7	1.2	1.6
Productivity	1.1	1.3	1.5
Industrial production	1.8	2.5	3.1
	Average level		
Inflation (GNP deflator)	4.7	3.6	3.1
Unemployment	5.2	6.0	5.9

NOTES: Growth rates for the projection period are compound annual growth rates calculated between the years 1990 and 2000. Level variables are averages for the years 1991 to 2000.

SOURCE: Data Resources, Inc./McGraw-Hill.

Science & Engineering Indicators – 1991

assumptions.) S&E employment changes vary substantially from 1990 to 2000 under the three alternative economic growth scenarios:

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[14] The economic assumptions used in the three projection scenarios (low, mid, and high) were provided by Data Resources, Inc./McGraw-Hill. The scenarios were run in the summer of 1991. Based on these assumptions, NSF's PC occupations modeling system generated estimates of projected total employment by sector. The occupational structure used by the Bureau of Labor Statistics was applied to the total employment projections.

The scenarios are *not* predictions; consequently, departures from the assumptions on which the scenarios are based may alter future outcomes significantly.

- *Low growth*—S&E employment is expected to expand by 13.6 percent;
- *Mid growth*—S&E employment is expected to expand by 20.6 percent; and
- *High growth*—S&E employment is expected to expand by 26.7 percent.

(See text table 3-4.)

Growth differs dramatically among the five major groups of S&E employment: engineers, math and computer specialists, biological scientists, physical scientists, and social scientists. As shown in text table 3-4, the principal beneficiaries of growth in the 1990s are expected to be math and computer specialists and engineers. Under the low-growth scenario, demand is particularly weak for physical, biological, and social scientists. Under all scenarios, growth is concentrated among the engineering and math and computer specialties. This degree of concentration raises a concern as to the ability of the supply system to adjust to meet this demand.

Supply Side Responses

There are many ways in which the supply system can adjust to meet this contingency of concentrated growth, including the following:

- Students presently enrolled can shift to high-growth majors.
- Recent graduates with related degrees can seek employment in high-growth fields.
- Experienced workers can seek retraining and become occupationally mobile into such jobs.
- Experienced workers with training in high-growth fields who are pursuing non-S&E careers can return to S&E employment.
- Those working in high-growth fields can extend their careers in those areas.
- Immigrants can make up some of the shortfall in high-growth areas.
- Later retirement could offset high demand.

The supply model needs to capture these various facets of flexibility in system operations. However, the amount of flexibility the supply model exhibits must be based on historical magnitudes (Collins 1988).

S&E Employment: Supply Side

On the supply front, there are many factors that must be considered. A large amount of attention is typically paid to the production of S&E college degrees at both the baccalaureate and graduate levels. Underlying demographic trends of prime college-age groups, their rates and trends in college attendance, their willingness to pursue S&E degrees, and their willingness to work in S&E jobs once they graduate must also be examined. Recent college graduates represent a flow of new S&E personnel into the supply system. (See "Demographic Trends: Recent S&E Graduates," p. 72.)

These flows of newly trained personnel are much smaller than the stocks of employed people in various S&E occupations. (See NSB 1989, pp. 77-80, for an extensive discussion of S&E labor market stocks and flows.) The stocks of employed persons in S&E occupations, in turn, are smaller than the total number of S&E personnel in the workforce. Take, for example, engineers. In 1989, there were 67,200 bachelors degrees awarded in engineering and about 1.6 million people employed in engineering jobs (not all of whom had engineering degrees). However, since World War II, the total number of engineering bachelors degrees earned in the United States exceeds 2.0 million. A very large percentage of these graduates are still in the workforce today. Thus, as important as the flows of new S&E graduates are in the supply system, these numbers are small compared to the stocks of people employed in S&E occupations and the number in the labor force who have training in S&E fields. Consequently, small changes in the behavior of experienced workers can have dramatic supply consequences. Supply models must capture the behavior of experienced workers through analysis of the longevity of S&E careers. Such models must also take into account the willingness and ability of S&E trained personnel to work in occupations that do not exactly match their training (Dauffenbach 1990). This latter concept is known as "field mobility."

Supply model simulations were run on each of the three demand scenarios.[15] Overall, the low-growth supply simulations show about a 4.0-percent overall surplus by 2000—a particularly slow growth scenario. (See figure 3-17.) Below average surpluses are shown for math and computer specialists and physical scientists, while surpluses for the other occupational groups are slightly above average.

The mid-growth scenario indicates approximate balance—only about a 0.5-percent overall surplus. The balancing effects of supply system operations leave only a small percentage difference between the field of highest comparative shortage and highest comparative surplus.

The high-growth scenario, which yields an overall 26.7-percent growth in demand in the 1990s, results in an overall shortage, but not a significant one. Overall, total

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[15] The S&E supply model used to produce these estimates was developed for NSF by Dr. Robert Dauffenbach under an NSF grant to Oklahoma State University. The current model builds upon an earlier model application (see Dauffenbach and Fiorito 1983).

Text table 3-4.
Projected science and engineering job growth

Occupational group	1990	2000 Low	2000 Mid	2000 High
Total scientists and engineers	3,060	3,476	3,689	3,877
Percentage change		13.6	20.6	26.7
Engineers	1,558	1,740	1,877	1,980
Percentage change		11.7	20.5	27.1
Math and computer specialists	658	839	883	931
Percentage change		27.5	34.2	41.4
Biological scientists	298	317	327	339
Percentage change		6.2	9.7	13.9
Physical scientists	246	265	277	289
Percentage change		7.5	12.5	17.6
Social scientists	300	315	325	338
Percentage change		5.1	8.4	12.7

SOURCES: Bureau of Labor Statistics and National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1991

supply equals 98.0 percent of total demand. There are only a few examples of detailed S&E occupations where the extent of the shortage exceeds 2.0 percentage points.

Unanswered Questions

The Questions. Despite modeling advances to assess S&E employment outlooks, uncertainty remains high on both sides of the supply/demand equation. The questions abounding on the *demand* side include the following:

- Will decreases in defense spending dramatically affect S&E labor markets?
- Will the threat of foreign competition drive U.S. manufacturers toward more R&D spending?[16]
- Will the generally slower growth prospects for the U.S. economy impinge on demand for S&E personnel (SRS 1988b)?
- Will the rebuilding of Eastern Europe lead to a surge in demand for capital goods that have sizable S&E components?
- Will Federal budget deficit problems lead to a slowing of Federal R&D spending?

As these questions show, the impacts of recent events do not lead in a consistent direction. Some lead to increases in demand; others, to decreases.

On the *supply* side, too, there are many unanswered questions:

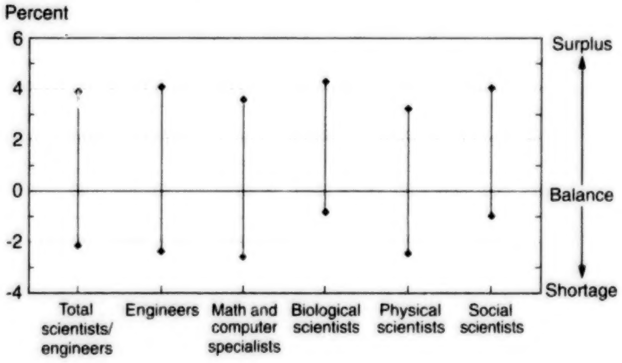
- Will the United States be able to continue its reliance on immigrants to fill Ph.D.-level jobs (Forrest 1990), or will rising international S&E demand begin to draw off this talent?
- Will the upheavals in Central and Eastern Europe and the former USSR, coupled with relaxation in emigration rules, lead to a massive exodus of S&E workers to the Western world?
- Will smaller youth cohorts in the prime college attendance years begin to have a dramatic impact on S&E degrees?
- Will women and minorities, who now make up a larger proportion of the college-age pool, begin to pursue S&E educational opportunities in increasing numbers (SRS 1990a, p. 31)?
- As larger proportions of S&E workers enter the 55 years and older age group, will retirements begin to have a much more significant supply impact?
- What are the implications of extending mandatory retirement to age 70?

As with demand, uncertainties in supply also do not point in the same direction.

Answer Lies in Supply Flexibility. The supply system reveals a fairly high degree of flexibility in the face of uncertain demand shocks. It is not infinitely responsive, however. Other factors limit its flexibility:

- The adjustment mechanisms the supply system incorporates are not without costs in lost productivity; retraining expenses; and employer, industry, and occupational mobility.
- In the high-growth scenario, it may prove difficult for higher education to respond to the demand for degrees in fields experiencing relative shortages.

Figure 3-17.
Estimated range of supply/demand differentials for scientists and engineers: 2000



SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1991

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[16] This circumstance could have a negative impact on demand for S&E workers if companies increase their fractions of R&D outside of the United States (where the labor involved is largely foreign nationals).

Moreover, since the more willing and sometimes more able are likely to be the first to engage in field mobility, the real and psychological costs of retraining and mobility will rise with each incremental need for change. It will prove increasingly costly to retrain personnel who are field-mobile to the areas of high demand.

As costly as such dislocations are, the supply system appears capable of adjusting to rather wide differentials in demand growth. The overall demand growth differential between the low and high scenarios is 13.1 percentage points (26.7-percent growth in the high-growth scenario versus 13.6-percent growth in the low-growth scenario). Supply system operations reduce this differential to half its former size: 2.0-percent shortage to 4.0-percent surplus, or a 6.0-percentage point differential. (That is, about half of the difference in demand between the high- and low-growth scenarios can be accommodated by adjustments in the supply system.)

Neither of these numbers represent a high degree of disequilibrium in the market for scientists and engineers. These demand scenarios and attendant supply processes can thus be said to exhibit relative *balance* for S&E labor markets in the 1990s. The possibility of spot shortages in certain S&E fields is not precluded, however. For example, the adjustment mechanisms in the supply system may be insufficient to meet the expected increase in demand for computer systems analysts.

Because of these many lingering uncertainties, S&E labor markets need to be followed closely and the scenarios and models improved continuously.

International Employment of Scientists and Engineers

A country's employment of scientists and engineers is a significant indicator of its level of effort in and relative national priority for science and technology. International comparisons are complicated by differences in countries' definitions of specific jobs and in methods of data collection and estimation. Still, international employment data provide insight into the relative strengths of the S&E workforces in the United States and other countries.

This section explores trends in international S&E employment, including employment sectors, primary activities, and employee characteristics in France, Italy, Japan, Sweden, the United Kingdom, the United States, and West Germany.[17] Also included is a brief discussion of trends in the emigration of foreign scientists and engineers to the United States. (See "Immigration," above.)

International S&E Job Patterns

In the early to mid-1980s, the number of nonacademic scientists and engineers employed in the United States exceeded the combined total of those in France, Italy, Japan, the United Kingdom, and West Germany.[18] Examining the number of scientists and engineers as a proportion of each country's total labor force shows that the United States employed the highest percentage of scientists and engineers, followed by (in descending order) Japan, West Germany, the United Kingdom, and France. Italy employed the lowest proportion of scientists and engineers. (See figure O-7 in Overview.)

In the five countries compared here (France, Japan, the United Kingdom, the United States, and West Germany), the services sector is usually the most important employer of scientists, while most engineers are employed in the manufacturing sector. In the 1980s, the services sector was the largest employer of nonacademic scientists in all countries except West Germany; there, manufacturing industries employed the largest percentage of these scientists. (See figure 3-18.) The manufacturing sector was the largest employer of nonacademic engineers in all countries; it was particularly significant in the United States and the United Kingdom, where it employed half of the engineers. The services sector employed the next highest proportion of nonacademic engineers in all five countries.

By occupation, industrial/mechanical engineers constituted over half of the S&E manufacturing workforce in the United States (1988) and the United Kingdom (1981). The proportion of these engineers was also high in France (1987) and West Germany (1985), where they accounted for between 43 and 45 percent of all scientists and engineers employed in manufacturing.

The distribution of the Japanese S&E manufacturing workforce differed from that of the other countries. In

Immigration

Immigrant scientists and engineers are an important component of the S&E workforce in the United States. They represent a valuable resource to the Nation's economy.

In 1988, 11,000 scientists and engineers immigrated to the United States. Forty-five percent of these immigrants came from Asia—three times the number that came from Western Europe. The largest numbers of immigrants came from India, Taiwan, The Philippines, and the United Kingdom, each of which accounted for more than 750 immigrants.

Almost three-quarters of the S&E immigrants to the United States were engineers. Only 11 percent of the new immigrants were in the natural sciences, 11 percent were mathematicians or computer specialists, and just 4 percent were social scientists.

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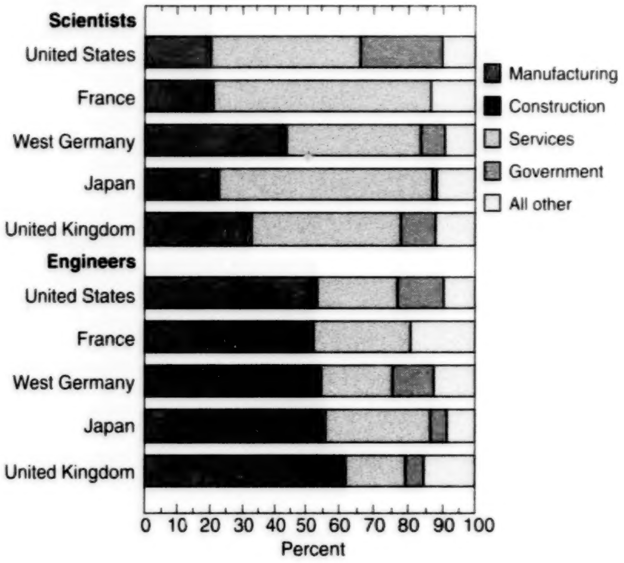
[17] Italy and Sweden are excluded from several discussion areas because of a lack of comparable data. West German data are for West Germany only and do not include data for the former East Germany.

[18] Academic S&E employment is excluded from this discussion because data are not available.

Figure 3-18.

Nonacademic scientists and engineers, by sector of employment



NOTE: U.S. data are for 1988; France, for 1987; West Germany and Japan, 1985; and United Kingdom, 1981.

See appendix table 3-18. *Science & Engineering Indicators – 1991*

Japan (1985), the largest proportion of its S&E manufacturing workforce was civil engineers (32 percent) and industrial/mechanical engineers (27 percent). Japan also had a higher proportion of computer specialists (21 percent) than did the other four countries.

R&D Activity

The United States had more full-time equivalent scientists and engineers engaged in R&D in 1987 than did Japan, West Germany, France, the United Kingdom, Italy, and Sweden combined. (See figure 3-19.) In fact, the United States had twice as many R&D scientists and engineers as Japan and about five times as many as West Germany: Japan and West Germany being the countries with the next highest numbers of R&D scientists and engineers. As a proportion of the labor force, however, other countries now have concentrations of R&D scientists and engineers approximating that of the United States. In 1987, Japan's ratio per 10,000 was close to that of the United States—68.8 versus 75.9, respectively.

Employee Characteristics

Age. The age profile of a country's S&E workforce is used as an indicator of how recently the population of scientists and engineers may have been trained. It also provides information on the potential need for replacements.

Japan has a younger nonacademic S&E workforce than do the other countries. Almost half of the nonacademic scientists and engineers in Japan (1985) were younger than 35. (See figure 3-20.) In comparison, slightly less than a third of U.S. nonacademic scientists and engineers were under 35 (1986). Moreover, Japan had the smallest proportion of scientists and engineers (7 percent) older than 55; the United States had the second highest (18 percent).

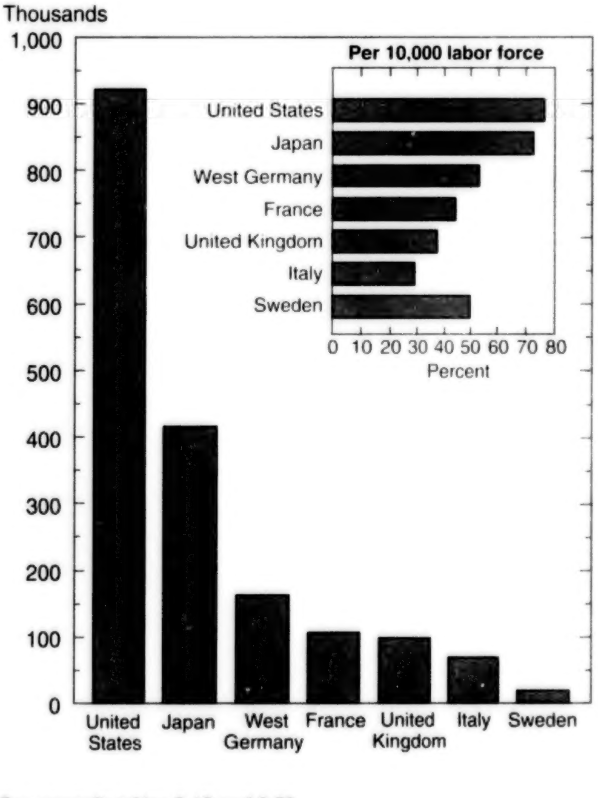
Internationally, most scientists and engineers were middle-aged: About half the scientists and engineers in France, the United States, and West Germany were between 35 and 54 years old.

Gender. The vast majority of scientists and, especially, engineers in all countries compared here were male. (See appendix table 3-17.) However, the fractions for female S&E employment are increasing—slowly in engineering and more rapidly in the sciences. France, the United States, and the United Kingdom had the best records of employing female scientists and engineers (14 percent, 13 percent, and 9 percent, respectively).

Educational Attainment. The quality of a nation's S&E workforce is greatly influenced by the level of education attained by its workers. Information on the field and level of S&E degrees awarded can therefore serve as a valuable indicator of the competitive potential of a country's workforce.

Figure 3-19.

Scientists and engineers engaged in R&D, for selected countries: 1987



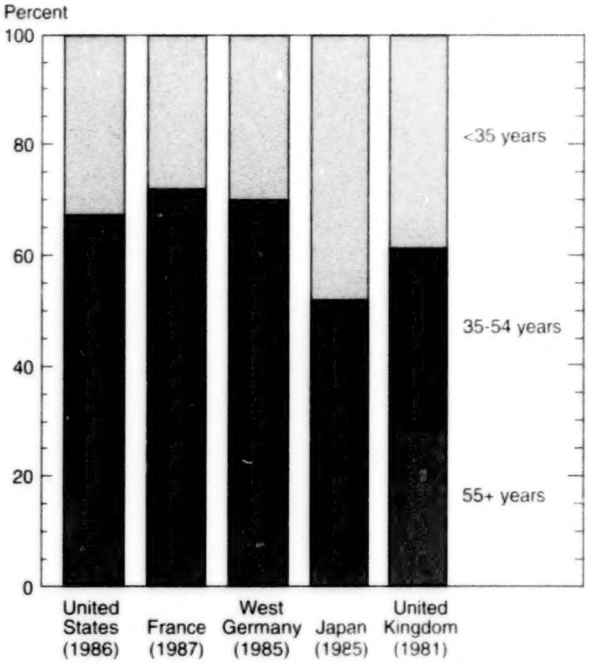
See appendix tables 3-19 and 3-20.

Science & Engineering Indicators – 1991

The United States (1988) and Sweden (1987) had significantly lower percentages of university graduates in the natural sciences and engineering than did the other five countries—20 and 12 percent, respectively. In contrast, in France (1987) almost half of first university degrees were awarded in either the natural sciences or engineering. Corresponding proportions were 37 percent in the United Kingdom (1988), 35 percent in West Germany (1988), 31 percent in Italy (1987), and 27 percent in Japan (1988). France, the United Kingdom, and West Germany all had greater concentrations of first university degrees in the natural sciences in 1986 than did the United States. In absolute numbers, however, the U.S. degree recipients were more numerous.

In 1988, more Japanese than U.S. students received first university degrees in engineering (76,000 versus 70,000) despite the fact that Japan's college-age population is only about one-quarter that of the United States. (See figure O-14 in Overview.) However, the United States awarded more than twice the number of engineering doctoral degrees and more than 10 times the number of natural science doctorates than did Japan in the same year.

Figure 3-20.
Nonacademic scientists and engineers, by age for selected countries



See appendix table 3-22. Science & Engineering Indicators – 1991

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Chapter 4
Financial Resources for Research and Development

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Financial Resources for Research and Development

HIGHLIGHTS

U.S. Research and Development (R&D)—the National Level

- **Growth in the Nation's R&D investments slowed in recent years.** U.S. support for R&D grew at an estimated average annual constant dollar rate of 1.2 percent between 1985 and 1991, one-sixth the rate of growth for 1980 to 1985. Total R&D expenditures reached an estimated $152 billion in 1991, or 2.7 percent of the gross national product (GNP). *See pp. 89-90.*

- **A decreasing fraction of U.S. R&D support is being provided by the Federal Government.** The Federal share of the Nation's R&D funding total edged downward, from 46 percent in 1985 to 44 percent in 1991. Industry's share of total was the same in both 1985 and 1991—51 percent. The combined share of support from state governments, universities, and nonprofit institutions rose from 3 to 5 percent. *See pp. 90-91.*

- **The university share of total U.S. R&D performance continues to grow.** Industrial firms' R&D performance accounted for 74 percent of the U.S. total in 1985 and 72 percent of national 1991 expenditures. The share of all R&D that was conducted in academic institutions grew from 12 to 15 percent over the same time period. Federal agencies accounted for 11 percent of the U.S. performance total in both years. *See p. 91.*

- **Federal R&D funding patterns reflect increased support for several nondefense policy objectives.** More than 90 percent of the growth in Federal R&D support from 1980 to 1986 was defense-related. Since then, the largest Federal R&D increases have been for health and space programs. Nonetheless, defense still accounted for 59 percent of the 1991 Federal R&D funding total. *See pp. 94 and 99.*

- **An increasing proportion of health R&D is funded by non-Federal sources.** Between 1985 and 1991, the Federal share of total health R&D dropped from 50 to 42 percent. Industry support grew from 40 to 47 percent of total. *See pp. 100-01.*

- **The use of Federal incentives to foster R&D growth and inter-sector research cooperation has increased rapidly**. Federal support for small business research has increased by more than 10 percent (in constant dollars) per year since 1985. Tax credits for R&D expenditures annually provide over $1 billion of indirect Federal support. More than 200 industry cooperative research ventures have been registered nationwide since 1985, and 868 cooperative R&D agreements between industrial firms and Federal laboratories have been negotiated since 1986. *See pp. 97 and 101-02.*

U.S. R&D—the State Level

- **U.S. R&D performance is concentrated in a few states.** Half of the 1989 nationwide R&D effort was undertaken in five states—California, New York, Michigan, Massachusetts, and New Jersey. However, New Mexico and Delaware had the largest R&D to gross state product ratios. *See pp. 103-04.*

- **States continue to be heavily involved in fostering R&D growth and research cooperation among sectors.** Since 1985, at least 30 states have established institutions promoting local economic development through science and technology. At least 36 states award university-industry research grants to support growth strategies; no fewer than 20 provide tax incentives for R&D conducted in-state. *See pp. 104-05.*

- **Industry support of the U.S. academic R&D effort rose from a 4-percent share in 1980 to a 7-percent share in 1989.** Industry support comprises a notably higher fraction—up to 20 percent—of academic R&D in states whose universities' research performance is relatively small. *See pp. 106-07.*

U.S. R&D—International Comparisons

- **The United States spent 16 percent more on R&D in 1989 than did Japan, West Germany, France, and the United Kingdom combined**. However, these four countries collectively spent 12 percent more on total nondefense R&D than did the United States. The United States, Japan, and West Germany each invested close to 3 percent of their respective GNPs on R&D. Excluding R&D for defense purposes, the U.S. R&D/GNP ratio (1.9 percent in 1989) trails those of Japan (3.0 percent) and West Germany (2.8 percent). *See pp. 107-08.*

- **Government R&D investment priorities differ among countries.** In the United States, France, and the United Kingdom, defense accounts for the largest share of total governmental R&D. Japan invests heavily in energy-related R&D, and industrial development accounts for the largest share of the West German Government's R&D total. *See p. 109.*

- **R&D activities are becoming increasingly global.** In 1989, the overseas R&D investment by U.S. companies was equivalent to 9 percent of industry's domestic R&D spending, compared to 6 percent in 1985. In 1988, foreign companies accounted for an amount equivalent to 11 percent of all industrial R&D expenditures in the United States, compared to their 9-percent share in 1985. *See p. 110.*

Introduction

Chapter Focus

Previous chapters focused on the *people* involved in science and technology (S&T) activities, including research and development (R&D). This chapter presents indicators of the *financial resources* devoted to the Nation's R&D base and of the growing complexity of inter- and intra-sector cooperative R&D relationships that have been forged during the past decade.

Despite their recent slowing, both public and private sector R&D funding grew considerably during the eighties. This growth is itself an indication of the heightened importance assigned to the R&D enterprise. Indeed, there is ample evidence that R&D is essential to the provision of public goods and services that benefit society as a whole; for example, R&D contributes directly to improvements in national defense, public health, and environmental quality. Several decades of study have documented the further contribution of private R&D investment to productivity growth and industrial competitiveness.[1] And, according to recent studies, even the basic research undertaken in academic institutions promotes industrial innovation and yields high economic returns to society.[2]

Alongside this growing recognition of the importance of R&D is an appreciation in recent years by public and private sector supporters of R&D of the need to leverage their R&D funds. It has become increasingly clear that (1) R&D done in Federal or university labs can benefit industry and, by so doing, enhance industrial competitiveness at both the local and national levels; and (2) Federal fostering of research cooperation within industry—so that companies might better maintain their technological competitiveness domestically and abroad—also serves the goals of the Nation.

Chapter Organization

The first section of this chapter describes broad patterns among R&D-funding and -performing sectors—the Federal Government, industry, academia, and nonprofit institutions. A brief overview is provided of developments during the past 30 years that have led to the present R&D setting. Also discussed is the *character* of these activities—that is, whether they are basic research, applied research, or development.

The second section considers the Federal role more closely. Transfers of Federal funds to the various R&D-performing sectors are detailed, with specific attention given to the funding agencies, the fields of research funded, and the various socioeconomic objectives—including both defense and nondefense—supported. Data are provided on several Federal incentives that were put in place during the eighties to foster R&D growth indirectly—for example, R&D tax credits and cooperative R&D agreements. Additionally, for the first time in the *Indicators* series, data are included regarding Federal funding of R&D through the Small Business Innovation Research Program.

The third section takes a state-level view of the U.S. R&D base. Topics covered include the geographic distribution of domestic R&D investment, the research intensity of states' economies, state programs for S&T-based economic development, and direct funding of R&D by the states and within their universities.

The concluding section builds on the U.S. national and Federal details by providing comparisons on similar R&D topics among major industrialized countries. Indicators include level of funding, sector funders and performers, R&D/gross national product (GNP) intensities, and government R&D objectives. The globalization of the Nation's R&D effort is also discussed.

National R&D Spending Patterns

The United States spent an estimated 2.7 percent of its GNP on R&D activities in 1991. This investment in the discovery of new knowledge—and in the application of knowledge to the development of new and improved products, processes, and services—totaled an estimated $152 billion.[3]

In this section, national R&D expenditure trends and sector-specific R&D funding and performance patterns are reviewed. Major turning points in R&D spending patterns over the past 30 years are suggested. The discussion concludes with a summary of 1991 R&D estimates.

Overview: 1960 to Present

The Nation's R&D expenditures have more than doubled (in constant 1982 dollars) during the past three decades, rising from about $44 billion in 1960 to an estimated $110 billion in 1991. (See figure 4-1.) Because this growth has come in spurts, the history of U.S. R&D funding consists of several distinct stages. The period from 1960 to 1967 was marked by rapid growth in total R&D spending: Inflation-adjusted increases averaged 5.7 percent per year. The growth was spurred, to a large extent, by massive Federal investment in military and

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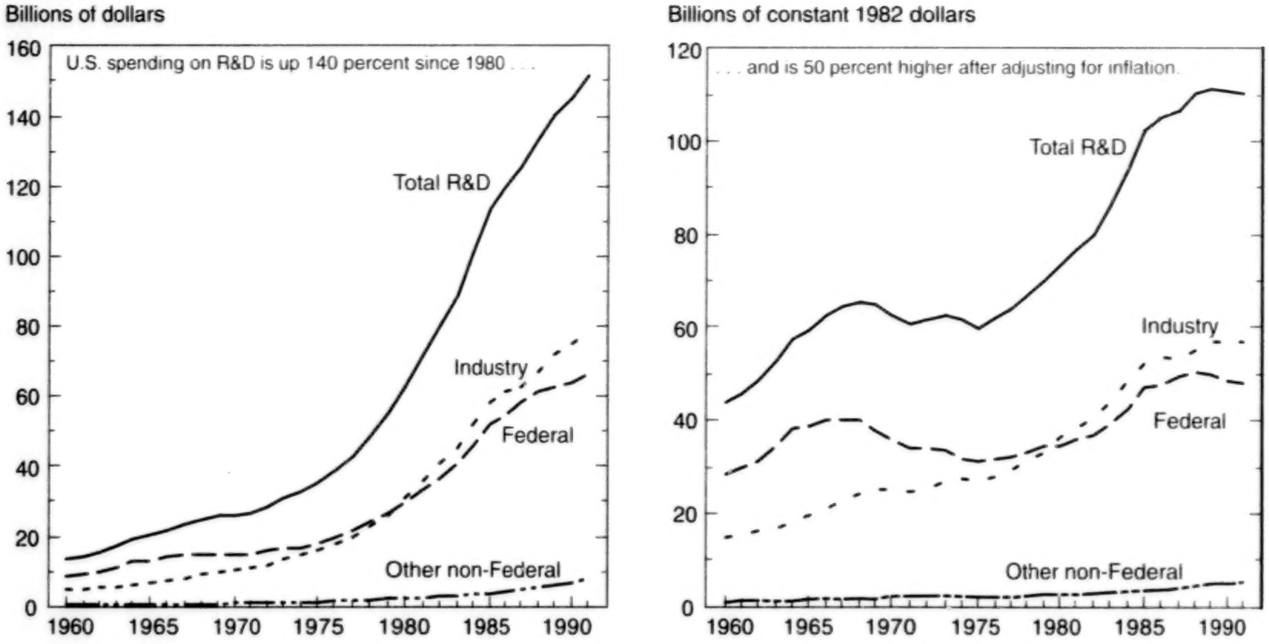
[1] Results from numerous econometric studies on R&D and productivity growth and related measurement and theoretical issues are summarized in Sveikauskas (1989).

[2] See Adams (1990) and Mansfield (1991). These benefits are in addition to the more traditional offshoots associated with basic research, including the education and training of future scientists and engineers and the pursuit of knowledge for its own sake.

[3] Throughout this chapter, current funding or expenditure data are presented in nominal dollars. Trend data usually are deflated to 1982 constant dollars using the GNP implicit price deflator and are so indicated. (See appendix table 4-1.) There are exceptions to this choice of deflator; these exceptions are identified appropriately.

Figure 4-1.
National R&D funding, by source



See appendix table 4-2.

Science & Engineering Indicators – 1991

space technology.[4] Then, for nearly a decade, total R&D growth failed to keep up with either inflation or economic output as both business and government—encountering an economic and political environment that could no longer justify the current rate of R&D expansion—deemphasized funding for research programs. In particular, Federal R&D support for both defense and nondefense activities declined sharply during this period. Overall, real R&D fell 9 percent, dropping from 2.8 percent of GNP in 1967 to 2.2 percent in 1975.

A significant funding reversal occurred following the dual energy and economic crises of the mid-1970s. From 1975 to 1985, U.S. R&D grew on average by 5.5 percent annually, and the R&D/GNP ratio climbed to 2.8 percent. Initially the research growth was directed toward solutions to energy problems; major energy R&D programs were undertaken by both industry and government. In the early eighties, however, the focus of the national R&D effort shifted overwhelmingly toward defense-related activities.[5] In fact, more than 90 percent of the rapid increase in Federal R&D support between 1980 and 1985 was attributable to defense programs.

Sluggishness in the economy (including attendant shortfall in profits, out of which business R&D normally is funded) and budgetary constraints imposed on all government programs have since slowed R&D growth nationwide. Even with the skyrocketing number of cooperative relationships among the various R&D-performing sectors of the economy—relationships generally established in response to regional or international competitiveness concerns—R&D growth has fallen overall to a 1.2-percent average annual rate of increase during the 1985-91 period. Indeed, a slight decline in inflation-adjusted R&D expenditures—fueled particularly by a reduction in defense R&D spending—is indicated from estimates for 1990 and 1991 (SRS 1991e).

Funders, Performers, and Character of Work

R&D Funders. Considerable changes in the patterns of R&D support and performance have accompanied the 30-year expansion of R&D investment chronicled above. The most notable change concerns the relative roles of the Federal Government and private industry in funding, or supporting, R&D. The Federal share of total national R&D expenditures has fallen rather steadily, dropping from 65 percent in 1960 to an estimated post-World War II low of 44 percent in 1991. Indeed, since 1988, not only has the Federal Government's *relative* share of the total fallen, but—after adjusting for inflation—so has its *absolute dollar* contribution. (See appendix table 4-2 for background data.) Also during the 1960-91 period, U.S. firms have increased their relative share of support for total U.S. R&D activities from 33 to 51 percent. This increased support includes both in-house R&D and funding of R&D in other sectors. University and college support for

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[4] Growth during this early period is a continuation of the rapid increases in the Nation's military R&D investment that began in the early fifties. From 1953 to 1960, U.S. R&D spending grew on average by 15 percent per year. The earliest year for which the National Science Foundation reports R&D expenditures is 1953.

[5] See SRS (1990b) for relevant statistics on energy and defense spending.

Definitions

The National Science Foundation uses the following definitions in its resource surveys.

Basic research: Basic research has as its objective a fuller knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific commercial objectives, although such investigations may be in fields of present or potential interest to the reporting company.

Applied research: Applied research is directed toward gaining knowledge or understanding necessary for determining the means by which a recognized and specific need may be met. In industry, applied research includes investigations directed to the discovery of new scientific knowledge having specific commercial objectives with respect to products, processes, or services.

Development: Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes.

Obligations: Obligations represent the amounts for orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when the funds were appropriated or when payment is required.

Outlays: Government outlays represent the amounts for checks issued and cash payments made during a given period, regardless of when the funds were appropriated or obligated.

Budget authority: Budget authority is the authority provided by Federal law to incur financial obligations that will result in outlays.

R&D—which includes state government support to this sector—has grown over the past three decades, rising from 1 to 3 percent of the national total. Most of this growth in academia's relative share has been in basic research. (See appendix table 4-4.)

R&D Performers. In terms of R&D *performance* patterns, the changes have been less pronounced. In contrast to its overall increased support for R&D, industry is estimated to have performed a smaller share of R&D in 1991 than in 1960: 72 versus 78 percent. Universities and colleges increased their share of R&D performance over the same period, rising from 5 percent to 11 percent of the national total. Particularly during the eighties, this growth in R&D performed on the Nation's campuses benefitted from steadily rising industry-university partnerships with both Federal and state government funding. Federal *in-house* R&D declined from 13 percent of the Nation's total in 1960 to 11 percent in 1991; it has remained level at approximately $12 billion per year (in inflation-adjusted 1982 dollars) since 1985. (See appendix table 4-2.)

Character of Work. Although the Nation's total investment in R&D has grown significantly, its relative emphasis by character of work (see "Definitions," above.) has remained rather stable since 1970. (See figure O-4 in Overview.) As a proportion of total R&D,

- Development has fluctuated between 61 and 66 percent;
- Applied research, between 21 and 24 percent; and
- Basic research, between 13 and 16 percent.

(See appendix tables 4-3, 4-4, 4-5, and 4-6.)

1991 Spending Patterns

R&D Funders. Funds for R&D in the United States came mainly from two sources in 1991—industry (at an estimated 51 percent of total) and the Federal Government (44 percent of total). The remaining 5 percent came from universities and colleges, state and local governments, and nonprofit institutions.[6] (See figure 4-2.)

The most recent estimates of change from 1989 to 1991 show Federal support declining 3 percent (in constant 1982 dollars), industry support remaining rather level, and support from other non-Federal sources climbing 15 percent. (See appendix table 4-2.)

R&D Performers. At an estimated $108 billion in 1991, industry remained the largest performer of R&D in the United States: R&D performed by companies ($105.8 billion) and that performed by industry-administered federally funded research and development centers (FFRDCs) ($2.7 billion) accounted for 72 percent of the national R&D effort.[7] About one-third of this combined industry and FFRDC performance total was financed by the Federal Government (see text table 4-1), mostly by the Department of Defense (DOD). Aerospace companies accounted for about one-fourth of industry's perfor-

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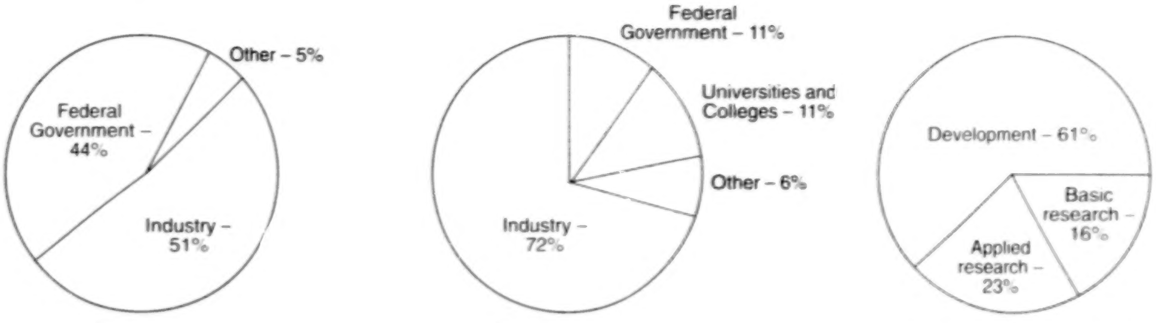
[6] Current estimates for state government *in-house* R&D are not available. In 1988, state labs' intramural performance reached $0.5 billion.

[7] An FFRDC is an organization exclusively or substantially financed by the Federal Government to meet a particular requirement or to provide major facilities for research and associated training purposes. Each center is administered by an industrial firm, an individual university, a university consortia, or a nonprofit institution. The 10 industry-administered FFRDCs receive the bulk of their funding from the Department of Defense and from the atomic energy defense programs of the Department of Energy.

Figure 4-2.
National R&D expenditures: 1991



By source **By performer** **By character of work**

See appendix tables 4-3, 4-4, 4-5, and 4-6.

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mance total; companies in the chemicals, communication equipment, and motor vehicles industries each accounted for about 10 percent.[8] (See appendix table 4-7, which also reports estimates for industry-specific character of work splits.)

The second largest R&D-performing sector consists of the Nation's universities and colleges, exclusive of university-administered FFRDCs.[9] Federal funding accounted for an estimated 56 percent of their R&D activities ($17 billion) in 1991; this was down from 68 percent in 1980. (See appendix table 4-2.) Academic institutions themselves financed a larger proportion of their R&D—14 percent in 1980 and an estimated 20 percent in 1991. Funds from industry to universities and colleges also increased over the period, rising from 4 to 7 percent of the total R&D performed in these institutions. State and

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[8] U.S. industrial R&D expenditures continue to be heavily concentrated in a small number of firms. In 1989, the four largest R&D-performing companies accounted for 22 percent of this sector's performance total. The 100 largest accounted for 70 percent of total (NSB 1991 and SRS 1991d). Fifteen years earlier, the 4 largest companies accounted for 20 percent of total and the 100 largest companies for 82 percent.

[9] One hundred universities accounted for about 82 percent of the R&D performed by this sector in 1989. Fifteen years earlier, the top 100 accounted for a similar 83-percent share of academia's total R&D effort.

Text table 4-1.
Estimated national R&D expenditures, by performing sector and source of funds: 1991

R&D performers	Total	Sources of R&D funds: Industry	Federal Government	Universities and colleges[1]	Other nonprofit institutions	Percent distribution, performers
	Millions of dollars					
Total	151,600	78,050	66,000	4,950	2,600	100.0
Industry	105,750	76,150	29,600	—	—	69.8
Industry-administered FFRDCs[2]	2,700	—	2,700	—	—	1.8
Federal Government	16,400	—	16,400	—	—	10.8
Universities and colleges	17,200	1,250	9,650	4,950	1,350	11.3
University-administered FFRDCs[2]	4,850	—	4,850	—	—	3.2
Other nonprofit institutions	4,200	650	2,300	—	1,250	2.8
Nonprofit-administered FFRDCs[2]	500	—	500	—	—	0.3
Percent distribution, sources	100.0%	51.5%	43.5%	3.3%	1.7%	

— = unknown, but assumed to be negligible

[1] Includes an estimated $1.5 billion in state and local government funds provided to university and college performers.

[2] Federally funded research and development centers (FFRDCs) conduct R&D almost exclusively for use by the Federal Government. Expenditures for FFRDCs therefore are included in Federal R&D support, although some non-Federal R&D support may be included in the totals.

See appendix table 4-2.

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local governments provided roughly 9 percent of the academic R&D total in 1991, slightly more than the 8-percent share the sector held in 1980.

Federal in-house R&D performance reached an estimated $16 billion in 1991, or 25 percent of all Federal R&D expenditures ($66 billion). Of this Federal funding total,

- 49 percent funded industry and affiliated FFRDCs;
- 15 percent went to universities and colleges;
- 7 percent funded FFRDCs administered by universities; and
- 4 percent was for institutions in the nonprofit sector, including FFRDCs administered by nonprofits.

(See text table 4-1.)

Character of Work. Development continues to account for the lion's share—61 percent—of U.S. R&D funds. An estimated 23 percent of the 1991 R&D total was for applied research; the remaining 16 percent was for basic research. Each of the sectors funds and performs basic research, applied research, and development to varying degrees. Different sectors, however, dominate in these R&D work categories:

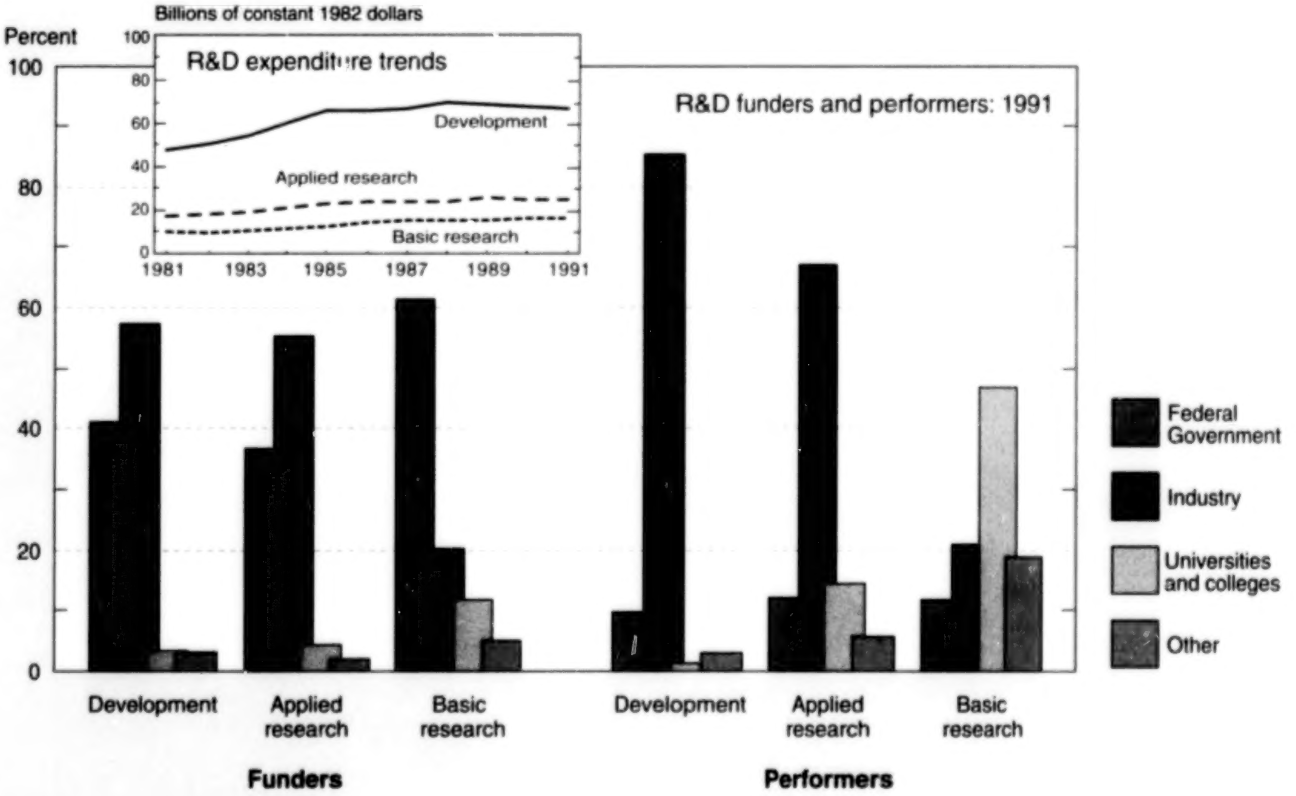
- In 1991, industry performed 86 percent and funded 58 percent of ***development***. The Federal Government funded almost all—41 percent—of the rest.
- Industry performed 68 percent and funded 56 percent of the ***applied research*** total.
- The Federal Government funded 61 percent of all ***basic research;*** 47 percent was performed by universities and colleges.

(See figure 4-3.)

Federal Support for R&D

Federal support for R&D is an important indicator of government's overall commitment to maintaining the Nation's S&T base and building its technological leadership. Undoubtedly, the most important means of Federal support for R&D is direct funding, which is now approaching close to $70 billion annually. This support includes funding for programs traditionally in the government purview—such as national defense—and for activities for which the government and the private sector share responsibility; for example, promoting long-term economic growth through small business research

Figure 4-3.
National R&D expenditures, funders, and performers, by character of work



See appendix tables 4-4, 4-5, and 4-6.

Science & Engineering Indicators – 1991

support.[10] Other key mechanisms of Federal support include the various tax and regulatory provisions that were enacted during the eighties to encourage greater research spending and cooperation among economic sectors. This section presents an overview of direct Federal R&D support, first by defining aspects and patterns of that support—character of work, agency, performer, and science and engineering (S&E) field—then by describing two specific R&D funding initiatives, and summarizing Federal R&D spending objectives. The section concludes with a discussion of indirect methods of Federal R&D support.

Federal Obligations for R&D

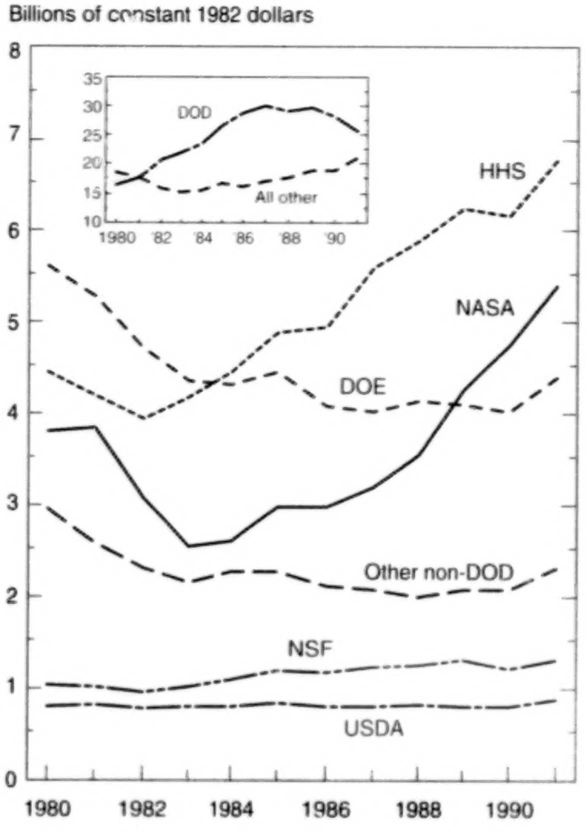
Federal R&D funding patterns over the past decade clearly reflect changing government investing priorities. The following sections explore these patterns and priorities by providing summary information on Federal R&D support by character of work, agency sponsor, category of performer, and scientific field of research support.[11]

Trends in Basic and Applied Research and Development. From 1980 to 1991, development obligations (see "Definitions," p. 91) grew by about 40 percent (in constant dollars), mainly because of defense-related R&D work, which is 90 percent development. Most of these gains, however, occurred early in the decade; since 1987, both development and defense spending have tapered off, and even declined. (See appendix table 4-8.)

Over the same 1980-91 period, basic (mostly nondefense) research grew by more than 60 percent, with most of the growth occurring since the mid-1980s. This growth exemplifies the prevailing government view of basic research as essential to the Nation's scientific, technological, and socioeconomic future. In contrast, Federal funding for applied research has been rather flat since 1980, reflecting the Administration's policy that private industry can respond to nongovernmental market needs better than can the Federal Government in making civilian applied R&D investment decisions.[12]

Patterns of Federal Agency Support. In 1991, the Federal Government obligated an estimated $68 billion in support of R&D and related facilities. Although some 25 Federal agencies contributed to this total, 95 percent of the 1991 Federal R&D support total was provided by just 6 agencies, as follows:

Figure 4-4.
Federal R&D obligations, by selected agency



See appendix table 4-8. *Science & Engineering Indicators – 1991*

- DOD, 55 percent;
- Department of Health and Human Services (HHS), 15 percent;
- National Aeronautics and Space Administration (NASA), 12 percent;
- Department of Energy (DOE), 9 percent;
- National Science Foundation (NSF), 3 percent; and
- Department of Agriculture (USDA), 2 percent.

(See appendix table 4-8.)

Since 1981, DOD has provided more R&D funds annually (for both in-house and external research) than all other agencies combined. (See figure 4-4.) This dominance in DOD's funding share peaked in 1986 at 64 percent of total and has since declined by about 10 percentage points.

HHS—and its National Institutes of Health (NIH) in particular—accounts for the second largest, and growing, share of the Federal R&D funding total. HHS is also the source of roughly 40 percent of Federal basic research funds disbursed nationwide, most of which are slated for research in the life sciences. Between 1986 and 1991, total R&D funding by HHS grew $4 billion, or

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[10] Recent research has uncovered a complementary *indirect* relationship between government R&D funding and private R&D. Link, Bozeman, and Leyden (1990) found that increases in Federal R&D contracts to firms are positively related (in a causal sense) to increases in industry's self-financed R&D. Furthermore, increases in government R&D to industry stimulate a greater sharing of firms' technical knowledge.

[11] See also OTA (1991) for a review of issues related to Federal research support.

[12] For a discussion of recent Federal S&T policy, see OMB (1991), Council of Economic Advisers (1991), and OSTP (forthcoming).

37 percent in constant dollars. A substantial amount of this funding was for AIDS/HIV research.

NASA's recent R&D budget has also climbed significantly. Like that of HHS, it was up $4 billion—an estimated 81 percent—during the 1986-91 period. One-third of NASA's estimated 1991 R&D budget is slated for the controversial Space Station Freedom.

In contrast with the R&D *growth* for NASA and HHS, DOE R&D programs have *declined* (after adjusting for inflation); research funding provided by NSF and USDA has been relatively *level* since the mid-1980s.

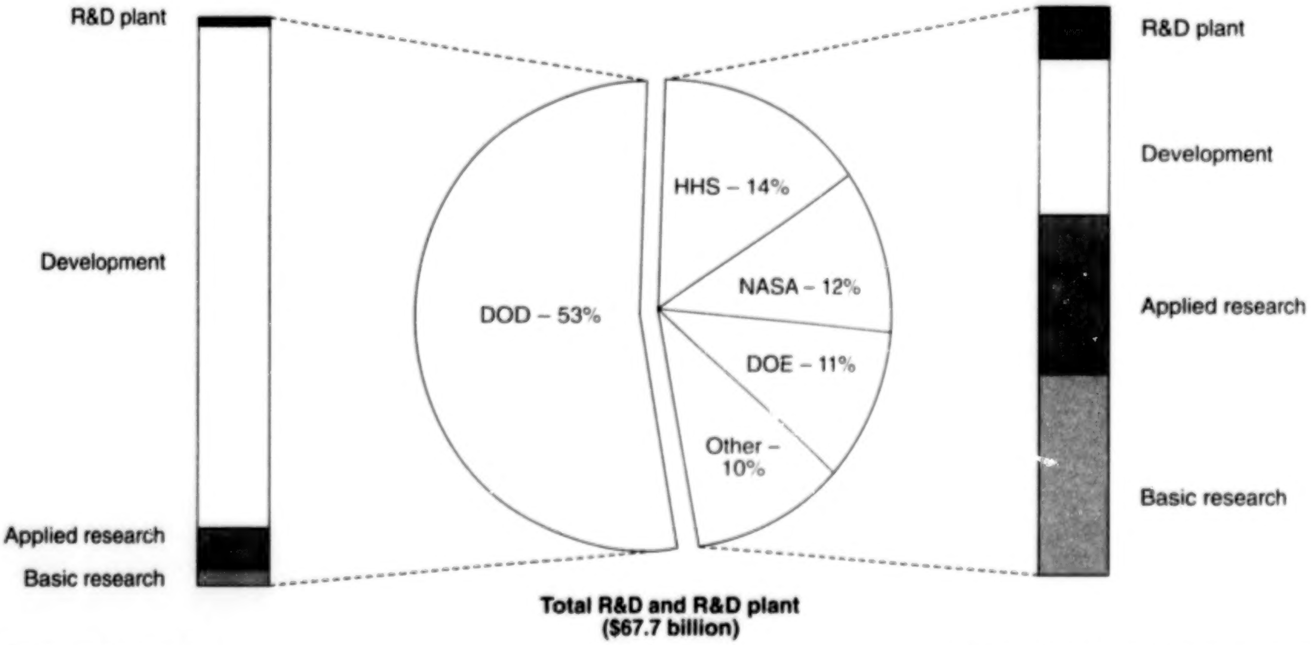
In terms of agency support by character of work, DOD emphasized programs in their development stage: Relatively little DOD funding was provided for basic or applied research. Aggregate funding by all other Federal agencies was more evenly distributed among the three R&D categories (about 30 percent of total for each); these agencies provided the remaining 10 percent of their total R&D funds for R&D plant projects. (See figure 4-5.)

R&D Agency-Performer Patterns. Over the years, one or two Federal funding agencies have come to provide the bulk of R&D support to each of the different types of R&D performers. For example, total Federal R&D obligations to FFRDCs are dominated by funding from DOE and DOD; the largest shares of R&D funds for academic and other nonprofit performers originate in HHS. (See text table 4-2 and appendix table 4-10.) Similarly, DOD, NASA, and DOE sponsor applied research within industrial firms and FFRDCs administered by either universities, industry, or nonprofit institutions. NIH, in contrast, expends the bulk of its applied research and development funds at nonprofit institutes and the research hospitals of the academic sector.

The largest recipient of basic research funds (in terms of estimated 1991 total agency obligations) is universities and colleges (47 percent); this sector is primarily funded by HHS (51 percent), NSF (24 percent), and DOD (9 percent). DOE, as in its support of applied research and development, is the largest provider of basic research funds to FFRDCs under contract with universities. Federal obligations for basic research in private firms are concentrated in the budgets of NASA and DOD. Federal in-house work on basic research programs is distributed among at least six major agencies, with the largest portions conducted at NIH and NASA laboratories. Smaller portions are performed at the Department of the Interior's Geological Survey and USDA's Agricultural Research Service. (See appendix table 4-9.)

Fields of Science and Engineering. Obligations for the life sciences dominate the Federal basic research support total. (See appendix table 4-12.) Such funding has grown steadily since the early eighties. (See figure 4-6.) By 1991, it accounted for 45 percent ($5.6 billion) of the Federal total ($12.3 billion). This growth—especially in the biological sciences—reflects the mission interests of NIH, the major funding agency for life sciences. DOE provides most of its funding for basic research in the physical sciences, which have also experienced steady growth over the past decade and now account for a 24-

Figure 4-5.
Federal obligations, by agency and type of activity: 1991



See appendix table 4-8.

Science & Engineering Indicators – 1991

Text table 4-2.
Estimated Federal R&D obligations, by agency and performing sector: FY 1991

Performer	Performer total Federal obligations	Primary funding source		Secondary funding source	
	—Millions of dollars—	—Percent—		—Percent—	
Total R&D	66,107	DOD	56	HHS	13
Intramural laboratories	16,396	DOD	55	NASA	16
Industrial firms	31,512	DOD	80	NASA	14
Industry-administered FFRDCs	2,062	DOE	83	DOD	14
Universities and colleges	9,191	HHS	54	NSF	16
University-administered FFRDCs	3,654	DOE	59	NASA	19
Other nonprofit institutions	2,302	HHS	62	NASA	10
Nonprofit-administered FFRDCs	482	DOD	65	DOE	29
Basic research	12,255	HHS	40	NSF	15
Intramural laboratories	2,782	HHS	36	NASA	20
Industrial firms	1,043	NASA	57	DOD	19
Industry-administered FFRDCs	194	DOE	93	HHS	5
Universities and colleges	5,721	HHS	51	NSF	24
University-administered FFRDCs	1,267	DOE	71	NASA	18
Other nonprofit institutions	1,077	HHS	69	DOE	13
Nonprofit-administered FFRDCs	68	DOE	90	DOD	6
Applied research	10,965	HHS	28	DOD	23
Intramural laboratories	4,084	DOD	25	NASA	20
Industrial firms	2,384	DOD	45	NASA	34
Industry-administered FFRDCs	311	DOE	77	DOD	8
Universities and colleges	2,635	HHS	62	DOD	10
University-administered FFRDCs	596	DOE	61	NASA	26
Other nonprofit institutions	720	HHS	64	NASA	8
Nonprofit-administered FFRDCs	70	DOE	60	DOD	13
Development	42,888	DOD	78	NASA	11
Intramural laboratories	9,530	DOD	80	NASA	12
Industrial firms	28,084	DOD	86	NASA	10
Industry-administered FFRDCs	1,557	DOE	83	DOD	17
Universities and colleges	835	HHS	53	DOD	34
University-administered FFRDCs	1,791	DOE	50	DOD	32
Other nonprofit institutions	505	HHS	44	NASA	25
Nonprofit-administered FFRDCs	345	DOD	88	DOE	11

DOD = Department of Defense
DOE = Department of Energy
FFRDC = Federally funded research and development center
HHS = Department of Health and Human Services
NASA = National Aeronautics and Space Administration
NSF = National Science Foundation

See appendix table 4-10.

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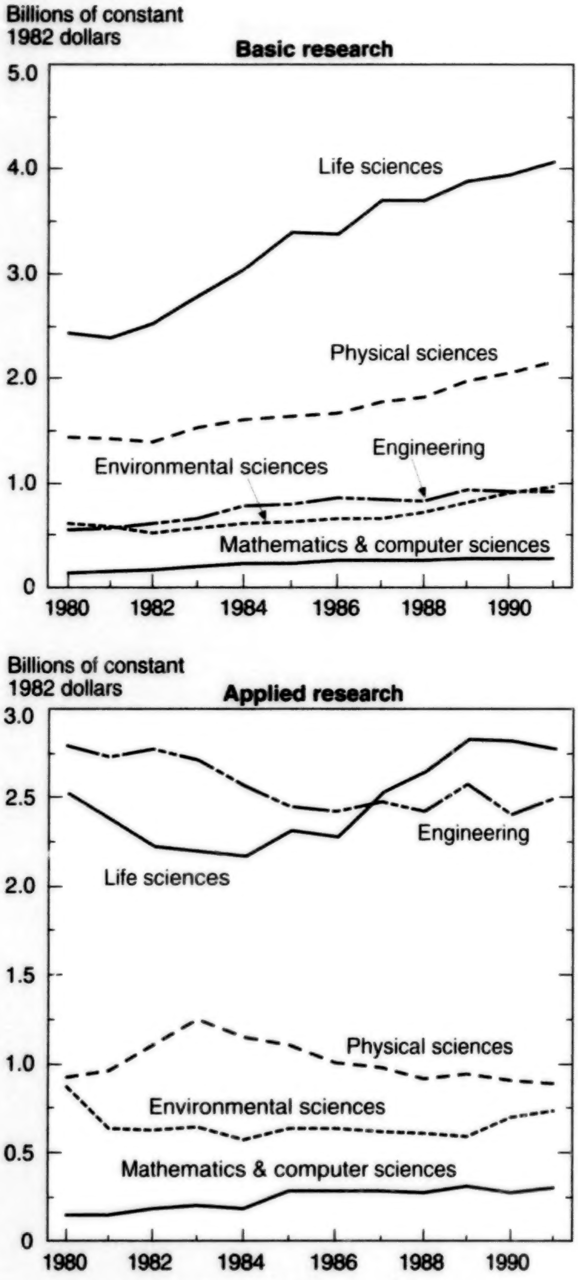
percent ($3.0 billion) basic research share.

The amounts obligated for applied research in Federal agency 1991 budgets were about three-fourths as much as estimated basic research obligations. Life sciences again received the largest funding support (see appendix table 4-13), and outstripped engineering in terms of relative shares: 35 percent versus 31 percent, respectively, in 1991. A decade ago, the funding shares of these two fields were reversed. This shift is explained not only by growth in the life sciences but also by a decline in engineering support (in constant 1982 dollars): Since 1980, Federal applied research support for engineering has fallen about 11 percent. Applied research funding for the physical sciences also fell in the 1980s, down approximately 30 percent since 1983.

An exception to these downward trends in Federal applied research support was the mathematics and computer sciences field, which grew nearly 9 percent per

Figure 4-6.
Federal obligations for research, by field



See appendix tables 4-12 and 4-13.
Science & Engineering Indicators – 1991

year from 1980 to 1991. Indeed, the largest rates of Federal growth in both basic and applied research funding were for mathematics and computer sciences. Total research for this field more than doubled (after adjusting for inflation) since 1980. Yet, however impressive the *rate* of funding growth, the *level* of support for this field changed only marginally—mathematics and computer sciences rose from a 2-percent share of the 1980 research total to an estimated 3 percent in 1991.

Small Business R&D[13]

Congress enacted the 1982 Small Business Innovation Development Act (P.L. 97-219) with the intent of strengthening the role of small innovative firms in federally supported R&D. Specifically, the statute created the Small Business Innovation Research (SBIR) Program; the Small Business Administration (SBA) was named as its coordinator. Under this program, when an agency's external R&D obligations (that is, those exclusive of inhouse R&D performance) exceed $100 million, the agency must set aside 1.25 percent of such obligations for SBIR projects. The SBIR Program encompasses the following three phases:

- **Phase I**. Phase I awards average $50,000 and are made to evaluate the scientific and technical merit and feasibility of an idea.
- **Phase II.** Phase I projects with the most potential are funded to further develop the proposed idea for 1 or 2 years. Most phase II awards are funded for less than $500,000.
- **Phase III**. Phase III is initiated when an innovation is brought to market by private sector investment and support. No SBIR funds may be used for phase III activities.

Eleven Federal agencies participated in the SBIR Program in 1989. (See appendix table 4-14.) From 1983 to 1989, obligations for SBIR awards totaled more than $1.8 billion; since 1985, they increased on average by more than 10 percent (in constant dollars) per year. Awards in 1989 alone—$432 million—accounted for 0.7 percent of all government R&D obligations. More than one-half of total SBIR obligations were disbursed by DOD, mirroring this agency's share of the Federal R&D funding total. (See figure 4-7.)

SBA classifies SBIR awards into various technology areas. (See appendix table 4-15.) In 1989, the advanced materials area received the largest share of phase I awards, and information processing was the leading technology area for phase II awards. Roughly one-fifth of all SBIR awards made during the 1983-89 period were computer-related, and one-fifth involved electronics. One-sixth of SBIR awards went to life science research; the bulk of such funding was provided by HHS. Materials-related research, which was funded largely by DOE and NSF, accounted for another one-sixth of total SBIR awards.[14]

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[13] This section deals with Federal funding of research activities in small businesses; much of this information is drawn from the Office of Innovation, Research, and Technology of the Small Business Administration (1990). See chapter 6, "Small Business and High Technology," pp. 157-160, for further discussion on the role of small businesses within the entire S&T system.

[14] For a relatively recent—and favorable—assessment of the SBIR Program, see GAO (1989a).

Independent Research and Development[15]

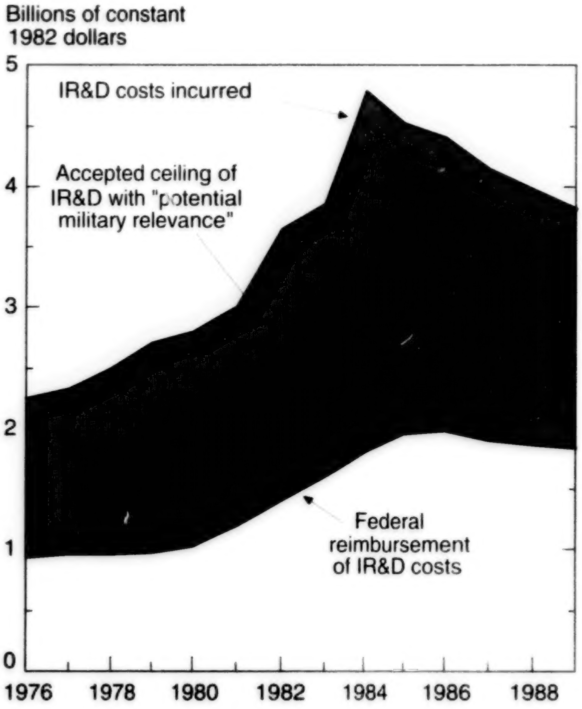
The Independent Research and Development (IR&D) Program enables industry to obtain Federal funding for R&D conducted in anticipation of government defense and space needs. Because it is initiated by private contractors themselves, IR&D is distinct from the R&D performed under contract to government agencies for specific purposes. IR&D allows contractors to recover a portion of their in-house R&D costs through overhead payments on Federal contracts on the same basis of reimbursement as for general and administrative expenses. All reimbursable IR&D projects must have "potential military relevance."

Briefly, the IR&D process is as follows: Contractors develop an IR&D plan, begin work, and then submit descriptions of all current and expected IR&D projects ("IR&D costs incurred" in figure 4-8). Subsequent transactions with the government may have marginal effects on these plans, but contractors proceed without awaiting government action. Following a DOD technical review of the plan, an advance agreement on the "allowable ceiling" for government reimbursement is negotiated as is the percentage of the costs that the government will reimburse.[16] This "fair share" percentage is in recognition of the fact that at least some part of industry's IR&D would have been undertaken solely or primarily for commercial purposes.

In 1989, industrial firms were estimated to have incurred $4.8 billion in IR&D costs, of which $3.8 billion were deemed to have potential military relevance. The government reimbursed $2.3 billion, or 48 percent of the IR&D total.[17] This figure is up from the 37-percent share—$0.9 billion—reimbursed in 1980; that is, at the start of the defense buildup early in the decade.

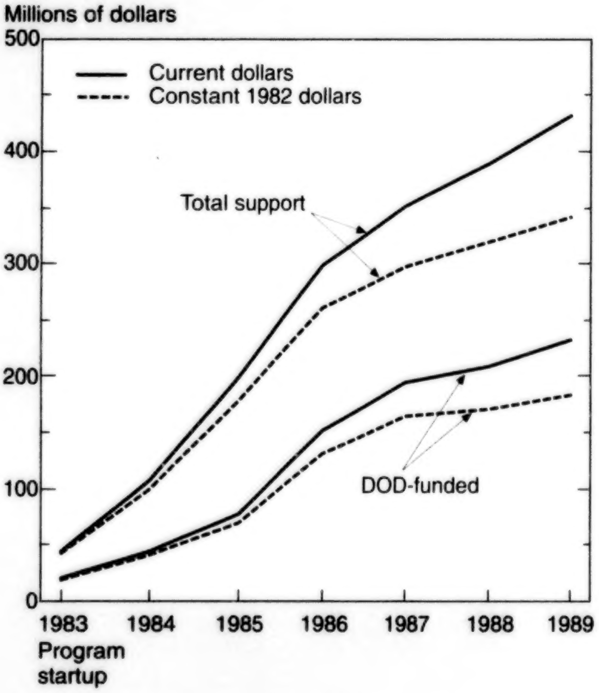
Both the amounts incurred and the amounts reimbursed have held rather steady since 1984: After adjusting for inflation, however, these funds have declined considerably. (See figure 4-8.) As an equivalent proportion

Figure 4-8.
Independent research and development (IR&D) costs and reimbursements



See appendix table 4-16. *Science & Engineering Indicators – 1991*

Figure 4-7.
Federal R&D obligations for Small Business Innovation Research awards



See appendix table 4-14. *Science & Engineering Indicators – 1991*

of combined DOD and NASA industrial R&D support, IR&D fell from 11.4 percent in 1984 to 8.5 percent in 1989. (See appendix table 4-16.) Given the more recent slowing in Federal defense R&D support overall, this downward trend in IR&D is likely to continue.

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[15] For a thorough discussion of the independent research and development process—including an assessment of its benefits, costs, and justifications—see Winston (1985) and Alexander, Hill, and Bodilly (1989). Material in this section is based largely on these reports.

[16] NASA also reimburses some IR&D costs and closely follows DOD procedures. During the 1980s, the NASA reimbursements typically ran less than 5 percent of those by DOD. DOE—or, more precisely, its predecessor agencies—used to reimburse IR&D but does not at present.

[17] The IR&D data reported here are for only the 100 or so major defense contractors whose accounts are audited and reported by the Defense Contract Audit Agency (DCAA), in accordance with P.L. 91-441. These companies did, however, account for approximately 97 percent of all IR&D; the remaining 3 percent was accounted for by some 13,000 other defense contractors (Alexander, Hill, and Bodilly, 1989, citing 1979 statistics). Unfortunately, 1989 may be the last year for which IR&D data are readily available. The fiscal year 1991 Appropriations Act repealed the provisions that required DCAA to collect IR&D data. DCAA consequently no longer intends to compile these statistics.

Federal R&D Support by National Objective

Funding Trends. The Office of Management and Budget classifies all activities within the Federal budget into 20 functional categories. There are 15 "functions" that contain Federal R&D programs.[18] Trends in Federal R&D functional funding patterns go a long way toward defining overall national R&D trends. In each of the past three decades, major Federal R&D growth spurts were concentrated in a specific function: in the sixties, space; in the seventies, energy, especially nuclear energy; and in the eighties, defense. (See figure 4-9.) In each case, the R&D focus mirrors the national policy objectives of the period, as indicated in Federal spending documents.

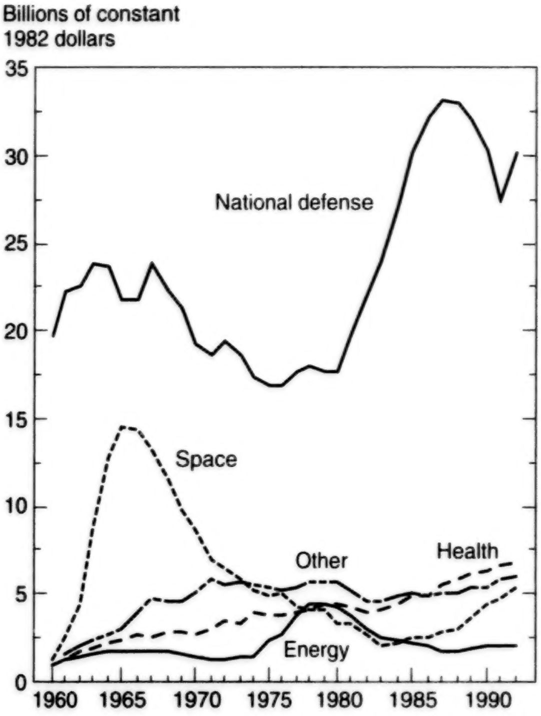
1992 Funding Patterns. Funding for health (41 percent) and general science (21 percent) dominate the estimated 1992 Federal basic research authorizations.[19] (See appendix table 4-18 and "Definitions," p. 91.) In terms of Federal budget authority for total research and development, the following five functions account for 92 percent of estimated 1992 funds:

- National defense—60 percent, including both DOD and DOE funds;
- Health—13 percent;
- Space—11 percent;
- General science—4 percent; and
- Energy—4 percent.

(See figure 4-10.)

Three other functional areas of Federal concern each accounts for between 1 and 3 percent of R&D budget authority: transportation, natural resources, and agriculture. Recent actions suggest increased near-term R&D funding for each of these objectives. For example, funding for USDA's new National Initiative for Research on Agriculture, Food, and Environment was provided in fiscal year 1991. This initiative is designed to focus basic, applied, and mission-linked research on the Nation's food, forest, and agriculture system with particular attention given to environmental compatibility issues, the contributing role of modern technologies such as biotechnology and computer sciences, and the international competitiveness of U.S. industries.[20] The need for increased transportation R&D is similarly recognized: As of this writing, Congress and the Administration were in mid-debate as to how best address the needs of the Nation's aging transportation infrastructure.

Figure 4-9.
Federal R&D funding, by budget function



See appendix table 4-17. *Science & Engineering Indicators – 1991*

Combined Federal and Non-Federal R&D Support by Objective

For any given socioeconomic objective, the Federal Government accounts for only part of the Nation's R&D total. And in fact, as was noted earlier, the Federal Government is providing a declining share of national R&D funding. Non-Federal sources, including industry and state governments, are consequently playing a much greater role today in determining the Nation's R&D funding priorities than they did 30 years ago. Although it would be difficult to distribute the national R&D total among specific categories of national objectives, this section attempts to provide a perspective on Federal and non-Federal R&D trends for defense, health, and agriculture.

Defense. Even for defense purposes, there is a substantial amount of private funds in addition to the

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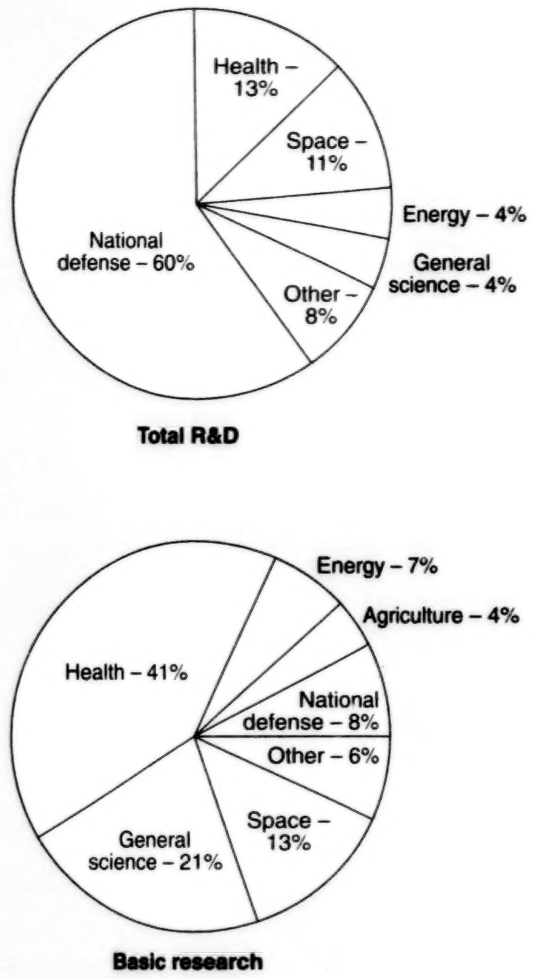
[18] For definitions and details, see SRS (1990a). Data reported here reflect estimates for R&D programs contained in the Administration's 1992 budget proposal submitted to Congress in February 1991.

[19] By definition, virtually no applied research or development work appears in the general science category. In contrast, health accounts for about 7 percent of applied and development work combined.

[20] For further details on the National Research Initiative, see Department of Agriculture (1991).

Figure 4-10.
Federal R&D funds, by budget function: 1992



See appendix tables 4-17 and 4-18.
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Federal funding component. Federal defense funding comprises DOD spending from its research, development, test, and evaluation (RDT&E) account; and DOE's R&D for its atomic energy defense activities. As was previously mentioned, industry funds considerable IR&D that is only partially reimbursed by the government but that nonetheless has potential military relevance. Adding these IR&D costs that are either reimbursed as overhead on defense contracts or not reimbursed at all increases total defense R&D by 9 percent for 1989.[21] This figure is down slightly from the 10-percent IR&D share of defense total indicated for 1980. (See text table 4-3.)

Health. As would be expected, non-Federal funding for national *nondefense* objectives plays an even more important role than does such funding for defense. For example, non-Federal sources for health R&D—primarily industry but also private nonprofit organizations such as the Howard Hughes Medical Institute—grew considerably faster than did Federal health R&D support during the eighties. (See figure 4-11.) According to NIH, public sector financing accounted for roughly two-thirds of the total health-related R&D in 1980; of this, about 60 percent was funded by the Federal sector, and the rest was funded by state and local governments. These sector shares had held rather steady since the mid-sixties. (See appendix tables 4-19 and 4-20.) By 1991, however, government's share of the estimated $25 billion health R&D total had fallen to just over one-half, with 42 percent of the total coming from the Federal Government—mostly NIH—and 7 percent from the states and localities. This decline in the Federal *share* was in spite of a 15-percent increase in the constant dollar support *level* over the

Text table 4-3.
National defense-related R&D support

	1980	1989
	—Billions of dollars—	
Defense-related R&D investments	16.2	43.9
Department of Defense RDT&E	13.4	37.5
Technology base	2.3	3.5
Advanced technology development	0.6	5.8
Strategic programs	2.2	6.4
Tactical programs	5.2	13.0
Intelligence and communications	1.2	4.5
Defense-wide mission support	1.9	4.2
Department of Energy defense R&D	1.1	2.6
IR&D with potential military relevance	1.7	3.8
Reimbursed ceiling	0.9	2.3
Unreimbursed ceiling	0.9	1.4

NOTES: Details may not sum to totals because of rounding. RDT&E = research, development, test, and evaluation; IR&D = independent research and development.

SOURCES: Science Resources Studies Division, National Science Foundation, *Federal R&D Funding by Budget Function*, annual series (Washington, DC: NSF); and Defense Contract Audit Agency, *Independent Research and Development and Bid and Proposal Cost Incurred by Major Defense Contractors*, annual series (Washington, DC: DCAA).

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same 11-year period.[22] Private sector support, led by the R&D investments of drug and biotechnology companies, grew by 125 percent between 1980 and 1989.

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[21] This particular accounting approach is suggested by Carter (1989) in addressing the revitalized policy-relevant issue of dual-use technologies; i.e., technologies with both military and civilian/commercial applications. In text table 4-3, DOD's "technology base" consists of all basic and applied research expenditures (6.1 fundamental research and 6.2 exploratory development monies in DOD's nomenclature). The rest is what NSF calls "development," including funds for the somewhat generic nonsystems "advanced technology development" work (6.3A in the DOD vernacular). See also Branscomb (1989) for a discussion of dual-use technologies.

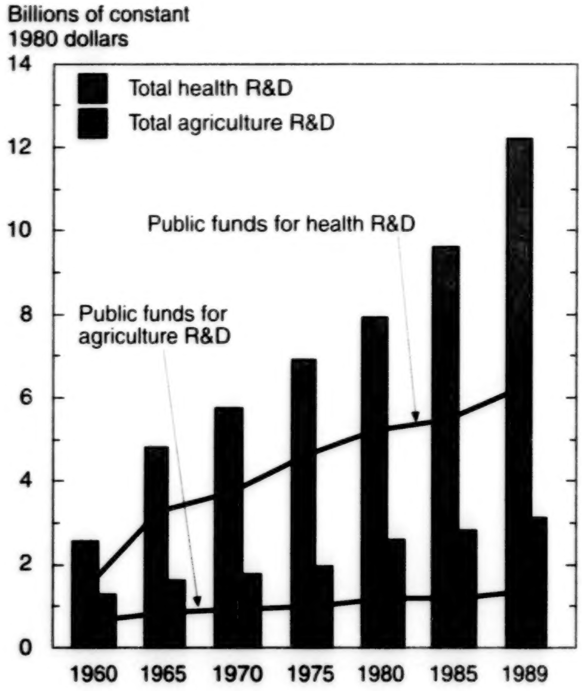
Food and Agriculture. As with health R&D, recent estimates show considerable private sector support for agricultural and food research; this support is, however, only one-quarter the level of private health-related R&D spending.[23] Public R&D support for agriculture also is about one-fifth that for health and is provided chiefly by USDA for in-house research by its Agricultural Research Service and Economic Research Service, and for extramural research by its Cooperative State Research Service. This last agency—along with state governments—contributes to the 57 state agricultural experiment stations affiliated, for the most part, with land-grant universities.

Spending on agriculture and food R&D was split rather evenly between the public and private sectors in 1975, with about $0.7 billion each. (See appendix table 4-20.) Since then, public agricultural research has fallen slightly to about 43 percent of the 1989 $5 billion national total; industry research has climbed to 57 percent. Neither source of support expanded very rapidly during the eighties. Increases in public spending averaged only 1.6 percent per year (in constant dollars) with the largest gains slated for the state agricultural experiment stations; industry support rose 2.5 percent annually. Industry's R&D expenditures for 1989 consisted of 40 percent food R&D and 60 percent R&D on agricultural inputs, mostly pesticides and farm machinery. R&D expenditures on biotechnology in food and agriculture grew from almost nothing in 1975 to an estimated $200 million in 1989—12 percent of all agricultural input industries' R&D.

Indirect Federal Encouragement of R&D

Improvement in global competitiveness and national economic welfare are central themes of current U.S. economic policy. To help achieve these goals, several Federal measures were put in place over the past decade, including incentive mechanisms specifically aimed at creating a more favorable environment for R&D investment and cooperative activities. Summary statistics for three such mechanisms—R&D tax credits, R&D consortia, and Federal cooperative research and development agreements—are presented in this section.[24]

Figure 4-11.
Public and private R&D expenditures for health and agriculture



NOTE: Separate deflators were used for health and agriculture.
See appendix table 4-20. *Science & Engineering Indicators – 1991*

R&D Tax Credits. Since 1981, the government has attempted to stimulate corporate spending through tax credits on incremental research and experimentation (R&E) expenditures.[25] The current tax credit is 20 percent for the amount by which a company's qualified R&D exceeds a certain threshold.[26] The Tax Reform Act of 1986 allowed companies to claim a similar credit for basic research grants, contributions, and contracts to universities and other nonprofit institutions. Since 1986 both credits have been annually renewed and were in place at least through the end of 1991.

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[22] Constant dollar estimates are based on the Bureau of Economic Analysis/NIH biomedical research and development price index. Using the GNP deflator on these health R&D data results in a 35-percent constant dollar increase in Federal support over the 1980-91 period and in a 230-percent increase in combined industry and nonprofit support. Since the index is designed to reflect price movements in biomedical R&D, it probably measures real changes in health R&D expenditures better than does the GNP deflator (Holloway and Reeb 1987). Pardey, Craig, and Hallaway (1989) similarly found reason to prefer an index specific to the agricultural research system over the GNP deflator. That price index is also used here to deflate these food and agriculture R&D data.

[23] Actually, these figures—recently made available by Dr. Carl Pray at Rutgers University—are for R&D *performance*, rather than *support*. In aggregate terms, however, there is little difference in choice of measures, since industry uses about 95 percent of its food and agriculture R&D funds for in-house activities and contract work to private research firms. Less than 1 percent of industry's in-house research is publicly funded (Pray and Neumeyer 1990).

[24] For a brief overview of recent policy provisions related to high-technology trade, see NSB (1989), pp. 158-60.

[25] Not all R&D is eligible for this credit, which is limited to expenditures on laboratory or experimental R&D.

[26] The current base structure for calculating a company's qualified R&D spending is complex and was put in place by the 1989 Reconciliation Bill, P.L. 101-239. (See Siboni and McCook 1990.) With various exceptions, a company's qualifying threshold is the product of a fixed-base percentage multiplied by the average amount of the company's gross receipts for the 4 preceding years. The fixed-base percentage is the ratio of R&E expenses to gross receipts for the 1984-88 period. See also a related analysis by Baily and Lawrence (1990).

As part of the budget process, the Treasury Department calculates the impact on Federal revenues of various preferential tax provisions, including the R&E tax credit. These estimates, called "tax expenditures," are calculated as the net difference between Federal revenues that would be collected with and without the preferential provision, given the otherwise current tax structure. In particular, Treasury provides outlay-equivalent figures for the R&E tax credit that are directly comparable to R&D budget outlays. (See "Definitions," p. 91.) These figures show that this indirect means of Federal R&D support ranged between roughly $1 and $3 billion annually over the past decade, an amount equal to about 3 percent of direct Federal R&D support. (See appendix table 4-21.) Based on early data from the Internal Revenue Service's *Statistics of Income,* companies taking the greatest advantage of the credit primarily have been large firms that produce scientific instruments, office and computing machinery, chemicals, and electrical equipment (see GAO 1989b and Cordes 1989).

R&D Consortia. Certain Federal provisions have been set in place to help foster cooperative relationships within the private sector. For example, the National Cooperative Research Act of 1984 (NCRA) encourages research collaboration among industry competitors by better defining joint research and development ventures (JRVs) and protecting them from antitrust suits.[27] NCRA also requires a public disclosure of JRVs, which subsequently appears in the *Federal Register.* Through April 1991, more than 200 filings of U.S. cooperative research ventures had been registered under the act. Up to one-half of the filings are for project-specific—often two-member—ventures; about one-fourth of the filings appear to be for industry consortia conducting long-term R&D and/or for research corporations with their own facilities.[28] Although the exact amount of R&D funded through JRVs or industry consortia is unknown, anecdotal evidence suggests that less than 2 percent of industrial R&D involves interfirm collaboration.[29]

Industry-Government Cooperative Agreements. The rise in the number of private cooperative research ventures has been accompanied by an increase in joint industry-government cooperative research arrangements. The Federal Technology Transfer Act (FTTA) of 1986 (P.L. 99-502) was enacted to promote the transfer of technology from Federal laboratories to state and local governments and the private sector. Approximately one-fourth of all Federal R&D funds support agencies' intramural research activities.[30] The act requires agencies to put the fruits of this R&D investment to commercial use. Specifically, FTTA authorizes government-owned and -operated laboratories to enter into cooperative R&D agreements (CRADAs) with private industry and to agree in advance on the rights of industry and Federal participants to resulting inventions.

The Federal Laboratory Consortium for Technology Transfer provides a support system to help U.S. firms capitalize on this Federal resource. Although it has taken several years for Federal agencies to make the necessary administrative arrangements, many have now successfully negotiated CRADAs with industry participants. (See DOC 1989.) By the end of fiscal year 1990, nine Federal agencies had entered into 868 cooperative agreements, with the number of active CRADAs growing substantially every year. USDA and HHS accounted for 85 percent of this CRADA total (DOC 1991).[31] (See text table 4-4.) Data on the dollar value of these CRADAs and other transfer activity indicators are not currently available.

State-Based R&D Expenditures

Many studies suggest that a critical mass of research is one of the fundamental requirements for high-tech industries to locate and grow in a region. (See Malecki 1980.) Also, an apparent lesson of state competitions in the eighties for major research institutions such as DOD's Sematech (a consortium to develop manufacturing technologies) and DOE's Superconducting Super Collider was that those institutions usually locate where major research and educational facilities are already established (Osborne 1989).

This section presents summary material on the geographic distribution of the U.S. domestic R&D effort. The analysis covers state R&D concentration levels—in

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[27] NCRA states that JRVs will not automatically be considered illegal as anticompetitive, but that such consortia will be judged after weighing potential benefits and costs. Further, NCRA limits potential liability for JRV behavior that ultimately is ruled anticompetitive to actual costs rather than treble damages as is otherwise the norm. See Link and Tassey (1989), Link and Bauer (1989), and Webre (1990).

[28] Any classification scheme for NCRA filings is bound to be somewhat subjective. Link and Bauer (1989) provided the framework used here. Complete filing information is available from the Office of Technology Commercialization (1991).

[29] See Webre (1990) and Bellcore (1990). In any event, most cooperative arrangements apparently are informal. For example, Link and Bauer (1989) estimate that up to 90 percent of all U.S. industry cooperative research arrangements in 1984 were informal partnerships.

[30] These R&D expenditures include administrative costs of intramural and *externally performed* R&D programs by Federal personnel.

[31] NASA relies on the National Aeronautics and Space Act of 1958, rather than FTTA, to guide its technology commercialization activities. Thus, although it enters into cooperative R&D agreements, these do not fall under the terms of FTTA. NASA estimates the number of its agreements similar to CRADAs as follows: 75 in 1987, 95 in 1988, 127 in 1989, and 147 in 1990. These cooperative research activities are *not* reflected in the above figures.

Other agencies—notably DOE—perform much of their research through government-owned and contractor-operated FFRDCs, rather than government-owned and -operated laboratories covered under FTTA; much of this research has commercial potential that is also not reflected in the above figures. The National Competitiveness Act of 1989 extended CRADA provisions to government-owned and contractor-operated FFRDCs, including those sponsored by DOE. As of July 1991, DOE laboratories had entered into a total of 24 CRADAs and were negotiating 19 more.

Text table 4-4.
Number of active cooperative R&D agreements, by agency

Agency	1987	1988	1989	1990
Total, all agencies	33	99	276	460
Agriculture	9	51	98	128
Commerce	0	9	44	82
Defense				
Air Force	0	2	7	13
Army	2	9	32	80
Navy	0	0	2	20
Energy	0	0	0	1
Environmental Protection Agency	0	0	2	11
Health and Human Services	22	28	89	110
Interior	0	0	1	12
Transportation	0	0	0	1
Veterans Affairs	0	0	1	2

NOTE: Not all cooperative agreeements are included under the provisions of the Federal Technology Transfer Act. See text.

SOURCES: Data submitted to the Technology Administration, Department of Commerce, by Federal agencies that own or operate laboratories.

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the aggregate and by sector—and indicators of the research intensity of state economies. Also included is information on recent trends in state government support for science and technology, including growth in the number of state-sponsored S&T programs and in state funding for R&D activities.

Distribution of R&D Funds by State[32]

Top 10 States. Of the $140 billion spent on R&D in the United States in 1989, almost one-half was spent in just five states (California, New York, Michigan, New Jersey, and Massachusetts). Moreover, more than two-thirds of the national R&D effort was performed in 10 states—the preceding five along with Texas, Pennsylvania, Ohio, Illinois, and Maryland.[33] (See figure 4-12.) Performance of R&D in California alone reached $31 billion (23 percent of the U.S. total); R&D expenditures ranged between $5 and $10 billion in each of the other nine leading states. (See appendix table 4-22.) In contrast, the smallest 30 states collectively accounted for $15 billion (roughly 10 percent) of the R&D conducted nationwide in 1989.

Not coincidentally, most of the states that are national leaders in total R&D performance also rank among the leading sites of industrial and academic R&D performance. (See appendix table 4-23.) For example, of the 10 states that led in total R&D,

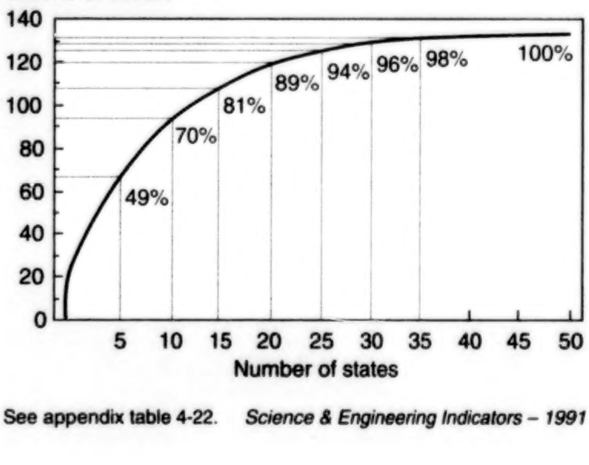
- All but 1 (Maryland) ranked among the top 10 industrial performers;
- All but 2 (Ohio and New Jersey) ranked among the top 10 academic performers;
- All but 2 (Michigan and New Jersey) ranked among the top 10 federally funded nonprofit performers; and
- All but 3 (New York, Michigan, and Illinois) ranked among the top 10 Federal intramural performers.

Furthermore, the 10 states that ranked highest in terms of R&D performance totals in 1989 were similarly ranked among the largest 10 in 1975.[34] The relative stability in research distribution indicates that leading R&D centers are not easily outcompeted, especially over short time periods.

R&D Intensity of States. The absolute levels of R&D expenditures noted above are indicators of the current breadth and scope of S&T activities within states. To some extent, they also indicate a state's potential for further supporting such activities. Programs designed to broaden states' R&D infrastructure are discussed below; however, to make more meaningful comparisons between states, indicators that normalize for the size of a state's economy are also discussed.

The ratio of R&D expenditures to GNP is used to gauge a country's commitment to R&D and to measure the change in this commitment over time. (For the United

Figure 4-12.
Cumulative distribution of R&D performance, by state: 1989



See appendix table 4-22. *Science & Engineering Indicators – 1991*

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[32] This section presents information on the state location of R&D performed by industry, academia, and Federal agencies, and the federally funded R&D activities of institutions that are part of the nonprofit sector. (See appendix table 4-22.) Consistent data on the state distribution of non-Federal R&D expenditures used by nonprofit institutions are not compiled. To account for differences in state sizes, these expenditure data are normalized by estimates of the states' economic activity.

[33] In this section, percentage shares and relative rankings are based on R&D performance expenditures that could be distributed among the states. Excluded from the $140 billion total are $2 billion of R&D performed in Washington, D.C., and an undistributed component of $5 billion. (See appendix table 4-22.)

[34] The exact ranking of these 10 did shift somewhat between 1975 and 1989. See SRS (1989).

States, the R&D/GNP ratio was about 3 percent in 1989.) Similarly, the ratio of in-state R&D performance to gross state product (GSP) can be used to measure the R&D intensity of a state's economy.[35] The largest R&D/GSP ratios were achieved in New Mexico (10 percent) and Delaware (6 percent). These two states were ranked 15th and 26th, respectively, in terms of total R&D performance. (See text table 4-5 and appendix table 4-23.) On the other hand, California and New York led the Nation in terms of total R&D performance but were 6th and 18th, respectively, in terms of their economies' R&D intensity—5 percent and 2 percent, respectively. The median R&D/GSP ratio was 1.5 percent in 1989: 25 states achieved a ratio higher than the median, and the ratio in 25 states fell below this figure.

Text table 4-5.
State ranking of total R&D performance and research intensity: 1989

Rank			
Total R&D	R&D/GSP[1]	Total R&D	R&D/GSP[1]
1 California	6	15 New Mexico	1
2 New York	18	26 Delaware	2
3 Michigan	5	4 Massachusetts	3
4 Massachusetts	3	10 Maryland	4
5 New Jersey	8	3 Michigan	5
6 Texas	23	1 California	6
7 Pennsylvania	15	29 Idaho	7
8 Ohio	13	5 New Jersey	8
9 Illinois	20	12 Washington	9
10 Maryland	4	13 Connecticut	10
11 Florida	27	37 Vermont	11
12 Washington	9	14 Missouri	12
13 Connecticut	10	8 Ohio	13
14 Missouri	12	17 Minnesota	14
15 New Mexico	1	7 Pennsylvania	15
16 Virginia	24	20 Colorado	16
17 Minnesota	14	34 Rhode Island	17
18 Indiana	21	2 New York	18
19 North Carolina	29	27 Utah	19
20 Colorado	16	9 Illinois	20

[1] Research intensity is measured as the ratio of in-state R&D performance to gross state product (GSP).

See appendix tables 4-22 and 4-23.

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State S&T Programs[36]

A key indicator of the level of growth in state support for S&T is the existence of state government organizations established specifically for S&T development. The following sections describe the burgeoning of state S&T institutions and programs put in place during the eighties to support regional S&T-based economic growth.

Overview.[37] In recent years, most states have created one or more programs designed to enhance their technological and competitive capacities.[38] Although these S&T initiatives are as varied as the settings in which they have been launched, most seem to share three common goals: job creation, business development, and economic diversification. According to the Department of Commerce's clearinghouse (see footnote 37), by the middle of 1991 all states could identify a lead agency, board, or commission responsible for the promotion of S&T-based economic development programs. No fewer than 40 of these entities were established during the eighties; six states put such institutional arrangements in place only within the past 2 years. (See appendix table 4-24.) Agency responsibilities vary enormously, ranging from the simple provision of information and advisory services to active participation in multimillion dollar technology programs. Although some initiatives are obviously much farther along than others, each generally is designed to improve the state's economic environment by

- Strengthening linkages among the state's financial, academic, and business communities;
- Promoting entrepreneurship; and
- Upgrading the overall scientific and technological base of the local economy by building on existing regional strengths.[39]

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[35] The Bureau of Economic Analysis has prepared GSP data through 1986 and is in the process of updating the data through 1989. GSP data used here were estimated based on annual state changes in employee compensation and proprietors' income. See Renshaw, Trott, and Friedenberg (1988)and appendix table 4-23.

[36] "S&T" is used here, rather than R&D, to emphasize the broad range of state activities in support of economic development based on science and technology.

[37] Information presented in this section is taken from a new data base developed by the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation in the Department of Commerce's Office of the Assistant Secretary for Technology Policy of the Technology Administration. The Omnibus Trade and Competitiveness Act of 1988 specified creation of the clearinghouse to serve as "a central repository of information on initiatives of State and local governments to enhance the competitiveness of American business through the stimulation of productivity, technology, and innovation and Federal efforts to assist State and local governments to enhance competitiveness."

The data base contains information on more than 100 different S&T program variables. The information contained here reflect data available as of August 1991. However, because programs are constantly coming into, and going out of, existence, accurate counts are difficult and there are bound to be a few errors of inclusion, interpretation, or omission. For another recent snapshot of state S&T programs, see Phelps and Brockman (1991).

[38] For a summary of states' historical involvement in S&T programs, see NSB (1989), pp. 98-101. For a detailed analysis of trends in the eighties, see Osborne (1988). Osborne (1989) provides a preliminary assessment of various state S&T mechanisms.

[39] This last point is in stark contrast to the type of state economic development programs prevalent in the sixties and seventies. Then, states often pursued a "smokestack chasing" practice of luring companies away from one state to relocate to another. Most S&T-based programs are concerned more with creating new businesses—spinoff companies—or modernizing existing in-state industries.

States have adopted several experimental approaches in fostering technology-driven development. Summary data on four of the more pervasive approaches are provided here. (See appendix table 4-24.) Two of these mechanisms—*research grants* and *research centers*—usually require heavy university participation; the other two—*R&D tax credits* and *business startup support*—affect only the industrial sector.[40] Although some states concentrate on the industrial sector and others focus on university-based research, most initiatives have a mixed university-industry orientation. States in the Northeast and Midwest—which were among the first states to initiate S&T programs in response to the downturn in their manufacturing sectors during the late seventies and eighties—generally seem to use a larger variety of S&T mechanisms than do other states. Five states—Arkansas, Indiana, Iowa, Kansas, and North Carolina—continue to use each of the four named development tools.[41] (See figure 4-13.)

Research Grants and Centers. An important component of most state technology development strategies is research grants. At least 36 states use this mechanism for promoting local growth. Research grants usually

- Are made to universities based on joint proposals from a university and a private sector sponsor,
- Are intended to strengthen the *applied* rather than *basic* research base,[42] and
- Require matching funds from the private sector.

This last requirement ensures that state dollars are leveraged with outside funding and provides some assurance that the proposed research has commercial potential.

Although research grants are distributed through various means, by far the bulk of the money flows through state-initiated research or technology centers. Such "centers of excellence" have been established in 27 states and usually are located at universities—or at least affiliated with them. The centers generally concentrate on a specific field of research, drawing heavily on the strengths of an associated university and/or major industries in the state.

Tax Credits and Startup Support. Often patterned after the Federal R&E tax credit (see "R&D Tax Credits," pp. 101-02), many states have designed their own tax incentives to encourage industry's in-state R&D investment. Provisions for R&D tax credits and/or exemptions are on the books in at least 20 states.

Many states also provide considerable S&T support for industry's post-R&D activities. In fact, no fewer than 31 states have given some kind of financial support for business startup programs, including either one-time capitalization or ongoing funding and oversight. Six states have seed capital programs to assist companies trying to develop a marketable product. Seven states have venture capital programs to assist developing companies that have established business plans and commercially feasible projects. Eighteen states have both.

State Funding of R&D

Growth in state R&D funding is a direct indicator of a state's commitment to the building of its S&T base. It is also an indicator of expanding inter-sector research linkages, given the university-industry cooperative requirements increasingly associated with state funding. Two different data sources using different methodologies show growth in state support of R&D.[43] And, although state funding is not necessarily the causal factor, these data also show increasing support by industry for R&D performed on the Nation's campuses—an aim of many states' S&T policies.

Funds for Academic R&D by State.[44] Universities reported about $1.2 billion of support for R&D from state and local government sources in 1989, an amount equivalent to 8 percent of total R&D performed by the academic sector. (See appendix table 4-22.) Broken out by state, these same data reflect differing state resource patterns and show the effects of different institutional mixes in individual states.

Ten states accounted for over 50 percent of total national academic R&D expenditures from state and local sources. Texas alone, with a strong tradition of direct state government funding of institutional activities, accounted for the

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[40] The programs covered here are not the only ones that states use to spur technological development. Other popular approaches include establishment of research parks—to encourage planned clustering of technology companies and foster university-private sector partnerships—and incubator facilities providing startup companies with below-market rates for office and lab space as well as shared clerical and computer services. A number of states also work with local Federal laboratories to assist small and medium-sized manufacturers to commercialize Federal technologies. Passage of FTTA in 1986 encouraged this development. (See "Industry-Government Cooperative Agreements," p. 102.)

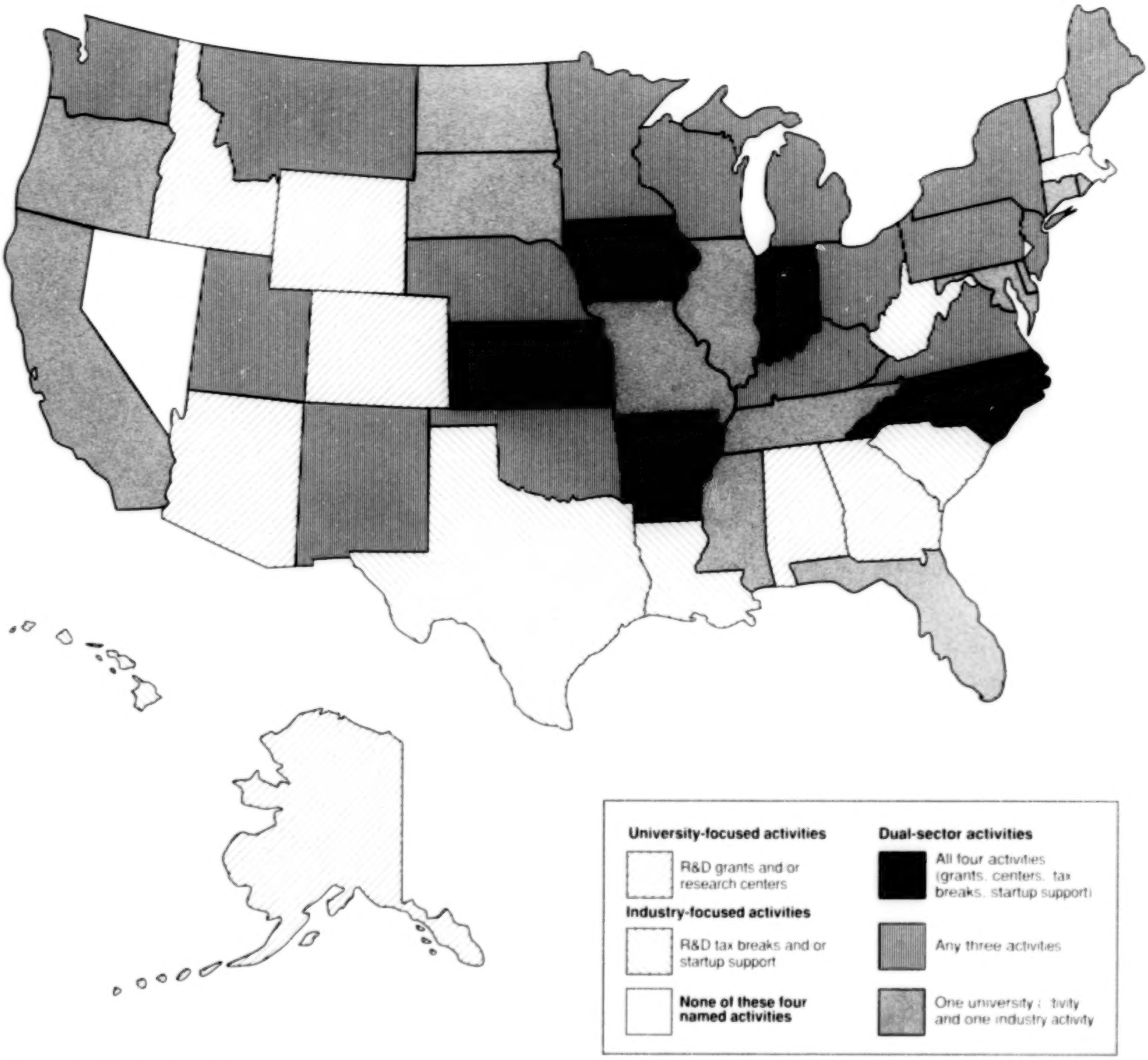
[41] Up until recently, Minnesota and Massachusetts also used all four S&T devices covered in this section. Minnesota discontinued its industry grant program in 1991 and merged two of its leading S&T institutions into a single entity. Massachusetts' S&T efforts underwent major restructuring during 1991, including the privatization of its six previously quasi-public Centers of Excellence. However, the state has enabled the creation of successor entities designed to continue the mission of S&T promotion. The newly formed Biotechnology Center of Excellence Corporation and the Massachusetts Foundation for Excellence in Marine and Polymer Sciences began operations in July 1991 and are stimulating S&T-based economic development in their areas of interest. In redefining the state role as one of facilitation, rather than program operation, the state legislature allocated no future funds for continued direct investment in many S&T programs that previously received state support (Phelps and Brockman 1991).

[42] That is, support of innovation and technology transfer for local economic development is the objective, and not the support of research for its own sake.

[43] The two NSF data sources are the annual Survey of Scientific and Engineering Expenditures at Universities and Colleges and the occasional Survey of State Government Research and Development.

[44] These data show only state and local government sources of funds that are separately budgeted for specific projects. General university funds used for academic R&D purposes are not included here. These data do not include R&D performed by university-administered FFRDCs.

Figure 4-13.
State promotion of S&T-based economic development


University-focused activities
R&D grants and or research centers
Industry-focused activities
R&D tax breaks and or startup support
None of these four named activities
Dual-sector activities
All four activities (grants, centers, tax breaks, startup support)
Any three activities
One university activity and one industry activity

NOTE: Data are as of August 1991.
See appendix table 4-24.

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largest share—10 percent—of nationwide non-Federal governments' R&D support to universities. These sources in Texas provided 12 percent ($124 million) of the funding for the state's total academic R&D. By comparison, universities in California—whose total R&D expenditure was the largest nationwide and nearly twice that of Texas in 1989—received 3.6 percent ($43 million) of its funding from state and local sources. This smaller proportion reflects (1) a large Federal funding share and (2) the presence of major private research universities that were less likely to receive state funding for R&D. (Nationally, private universities received only 2.4 percent of their R&D funding from state and local governments, compared to an 11.3-percent share at public universities.)

As a percentage of a state's academic R&D total, the state and local government share is relatively most important to universities in South Dakota—whose total R&D expenditure in 1989 was the smallest in the Nation—where it provided almost 40 percent of funds. Indeed, in many states where the academic R&D expenditure total was comparatively small, state government provided a relatively large proportion of the funding total. (See text table 4-6.)

Insofar as state S&T policy objectives include encouragement of university-industry interactions, industry support of university R&D may serve as one indicator of the success of those policies.[45] For all states combined, industrial sources of support for academic R&D have grown faster than all other sources of support, increasing 179 percent in constant dollars from 1980 to 1989. Support from other sources was up 60 percent. (See appendix table 4-2.) As a percentage of the Nation's total academic R&D effort, industry sources of support increased from 4 to 7 percent. Some states obtain a notably larger than 7-percent share of their academic R&D from industrial sources. This point is startlingly true of states in which university R&D performance is rather small. For example, total R&D activities on the campuses of Maine—$20 million—ranked that state 49th nationwide in 1989; yet industry provided a Nation-leading 20-percent share of total. (See text table 4-6.) Indeed, of the eight states that received the proportionately largest shares (10 percent or more) of their academic R&D funding from industry, six—Maine, Idaho, Nevada, Delaware, West Virginia, and Montana—ranked among the smallest nine states in terms of total academic R&D performance levels.

Text table 4-6.
States where non-Federal government and industry comprise the largest shares of academic R&D funding: 1989

		Support for academic R&D				
Rank, total academic R&D		Non-Federal government share (percent)	Rank	Industry share (percent)		Rank, total academic R&D
	U.S. averag͏e	8.2		6.6	U.S. average	
51	South Dakota . .	39.4	1	20.0	Maine	50
38	Hawaii	35.0	2	12.7	Idaho	46
41	Arkansas	27.9	3	12.1	New Mexico . .	29
37	Mississippi	27.3	4	12.0	Pennsylvania .	6
34	Nebraska	24.5	5	12.0	Nevada	45
46	Idaho	24.4	6	11.0	Delaware	44
47	Montana	24.4	7	10.1	West Virginia .	43
26	Louisiana	24.0	8	10.0	Montana	47
33	Kansas	22.4	9	9.9	Missouri	19
17	Virginia	19.0	10	9.7	North Carolina.	9
18	Minnesota	16.4	11	9.7	Nebraska	34
13	Wisconsin	16.4	12	9.4	Arkansas	41
15	New Jersey . . .	15.9	13	9.1	North Dakota .	48
23	Tennessee	15.1	14	9.1	Massachusetts	5
30	South Carolina .	14.5	15	8.9	Kentucky	35
9	North Carolina .	14.4	16	8.5	Georgia	10
28	Oregon	12.9	17	8.4	Virginia	17
3	Texas	12.3	18	8.2	Vermont	42
24	Iowa	11.9	19	8.1	Indiana	20
11	Ohio	11.8	20	7.9	Rhode Island .	36

See appendix table 4-22. *Science & Engineering Indicators – 1991*

State Agency R&D Expenditures. Although the most recently available NSF data on state agencies' R&D support are for 1988, their inclusion here provides for a more comprehensive overview of state R&D involvement. (See appendix table 4-25.) These data are only for state government expenditures that flow through state agency budgets; they therefore exclude, for example, all other funding for R&D activities by universities and colleges—including direct appropriations from state legislatures.

Like the academic data reported above, total state agency expenditures for R&D from state sources of funds have increased overall, doubling between 1977 and 1988 to about $630 million (in constant dollars). Nevertheless, these expenditures still accounted for only 1 percent of the national R&D funding total. State agency support for R&D facilities rose dramatically, resulting in a more than tenfold inflation-adjusted increase to $160 million. Some states, however, reported declines in real dollars. Care should be taken in using these data, because states differ considerably in their reliance on state agencies to disburse R&D funds. Some states appropriate most funds *directly* to institutions themselves, and this source of support for R&D is not reflected in these data.

International Comparisons

Comparisons of S&T activities between the United States and other major industrialized nations provide an indication of the strength of each countries' overall S&T endeavors. The success of these endeavors depends in part on the adequacy of financial R&D inputs; comparisons of international R&D spending patterns are provided in this section.[46] Performer and source expenditure patterns are contrasted, trend data reviewed, and spending by socioeconomic objective summarized. The section closes by placing the U.S. industry R&D effort in a global context.

R&D Funding by Source and Performer

The United States spent more money on R&D activities in 1989 than did any other country; in fact, it spent more than the next four largest performers—Japan, West Germany, France, and the United Kingdom—combined.[47] (See appendix table 4-26.) By sector, national governments and industry dominated as a percentage of each country's respective R&D funding and performance totals. Shares for these sectors, however, differed substantially from one country to the next. Although government was the source of 45 to 50 percent of R&D funds in the United States and France, it provided somewhat less in the United Kingdom (37 percent) and West Germany (33 percent), and considerably less in Japan (19 percent). (See figure 4-14.) Since 1975, government funding shares in all five countries declined, dropping most sharply in the United Kingdom (15 percentage points) and West Germany (14 percentage points). With the exception of France, industry provided more than half of the R&D funds in each of these countries in 1989. It provided 72 percent of Japan's R&D total.

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[45] See Feller (1990) and Berman (1990) for contrasting views on the role of universities in industrial development activities.

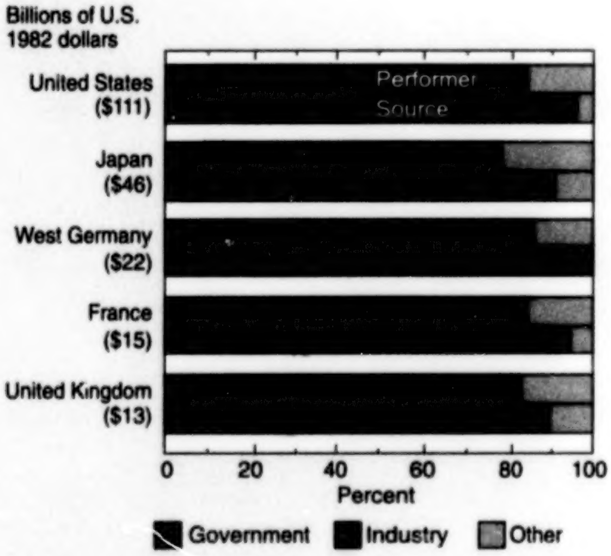
[46] R&D data for the major industrialized countries are obtained from reports to the Organisation for Economic Cooperation and Development (OECD). Few R&D data are systematically collected for developing countries; UNESCO reports such estimates where they exist. Although there is a fairly high degree of consistency in the R&D data reported by OECD, data for countries reporting to UNESCO are less comparable—principally because of differences in national statistical collection capabilities and definitions. For a summary of the UNESCO and OECD data, see SRS (1991c).

[47] Data for Germany are for West Germany alone. R&D expenditures in the former East Germany are not included.

Industry was the largest R&D performer in each of the five countries, with shares ranging from 60 percent in France to 72 percent in both the United States and West Germany. The industry R&D performance share grew most rapidly in Japan—from 57 percent of total in 1975 to 70 percent in 1989.[48] (See appendix table 4-28.) Government as an R&D performer was relatively smallest in Japan and the United States, accounting for 8 and 11 percent, respectively, of each country's R&D total. Government's R&D performance—including that in several nonprivatized industries—accounted for about one-fourth of France's R&D effort.

The United States and Japan devoted about the same proportion of their investments to basic research: 14 percent and 13 percent, respectively, in 1988. (See appendix table 4-29.) In dollar terms, the U.S. basic research investment ($15 billion) was three times that of Japan ($5 billion). West Germany spent 19 percent of its total R&D on basic research ($4 billion), compared to 23 percent for France ($3 billion).[49]

Figure 4-14.
International R&D funds, by performer and source: 1989



See appendix table 4-28. *Science & Engineering Indicators – 1991*

R&D Funding as a Percentage of GNP

Total R&D. R&D expenditures as a percentage of GNP have become one of the most widely used indicators of a country's commitment to scientific knowledge growth and technology development. The industrialized nations of France, West Germany, Japan, Sweden, the United Kingdom, and the United States each maintained an R&D/GNP ratio of between 2 and 3 percent throughout the eighties. (In Italy, this ratio rested near 1 percent.) Generally, the R&D/GNP ratio increased annually in these countries, although the rate of change varied somewhat. The approximate 2.7-percent R&D/GNP ratio of the United States in 1989 was about half a percentage point higher than its 1980 ratio. (See figure O-2 in Overview and appendix table 4-26.) Even with this growth, the U.S. R&D/GNP ratio did not keep pace with the same indicator in Japan and West Germany, whose ratios were 2.9 and 3.0 percent, respectively. And, in spite of a recent decline in its R&D/GNP ratio, Sweden also invested a slightly larger GNP share on R&D (2.8 percent in 1989) than did the United States. In dollar terms, however, Sweden's R&D expenditures were only 3 percent of those in the United States.

Nondefense R&D. Differences in R&D emphases among these countries become clearer when the data are disaggregated. Nondefense R&D expenditures as a percentage of GNP in both Japan (3.0 percent) and West Germany (2.8 percent) considerably exceeded those of the United States (1.9 percent); they have done so for more than two decades. (See figure O-2 in Overview and appendix table 4-27.) The nondefense R&D ratios of France (1.8 percent) and the United Kingdom (1.6 percent) were only slightly below that of the United States.

In absolute dollar terms, the U.S. international position was markedly different from that indicated by the nondefense R&D/GNP ratios. Between 1972 and 1989, only Japan and Italy had increased nondefense R&D spending (up 207 and 97 percent, respectively, in constant dollars) at a faster rate than had the United States (up 88 percent).[50] The result is that as a percentage of the U.S. nondefense R&D total, comparable Japanese spending jumped from 35 percent in 1972 to 58 percent in 1989. (See figure 4-15.) Japanese nondefense R&D reached $46 billion in 1989, compared with the $79 billion U.S. nondefense R&D total. Italy's nondefense R&D grew from an amount equivalent to 8 percent of the U.S. nondefense R&D total in 1972 to 10 percent ($8 billion) in 1989. West

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[48] Detailed and more extensive data can be found in SRS (1991c).

[49] Comparable data for the United Kingdom are extremely outdated. The most recent figure (1981) indicates, however, that the basic research share was 13 percent.

[50] See appendix table 4-26 for details on conversion of national currencies to dollars.

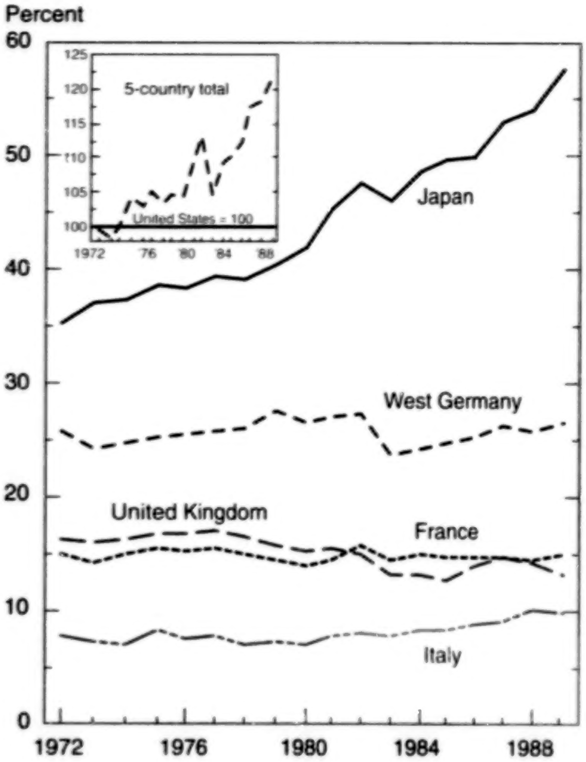
Germany spent an amount equal to about 26 percent of U.S. spending on nondefense R&D in both years ($21 billion in 1989), while France annually spent an amount equivalent to about 15 percent of the U.S. total ($12 billion in 1989). United Kingdom nondefense R&D spending fell by 3 percentage points relative to that of the United States, dropping to 13 percent or $10 billion.

R&D by Socioeconomic Objective[51]

Countries' relative shares of government R&D appropriations (excluding general university funds—GUF) reflect marked differences in national priorities. In the United States, 66 percent of total 1989 Federal investment in R&D was devoted to national defense, compared to 55 percent in the United Kingdom, 42 percent in France, 19 percent in West Germany, and 9 percent in Japan.[52] (See text table 4-7.) The U.S. Government also emphasizes health-related R&D (13 percent of total); this emphasis was especially notable in its R&D support given to academic and similar institutions.[53]

Energy-related activities accounted for 39 percent of Japanese Government R&D appropriations in 1989, reflecting the country's concern with its high dependence on foreign sources of energy. The Government of West Germany invested considerably in R&D related to industrial development and the advancement of research (each about one-fifth of the government total) as did France with 15 and 18 percent, respectively, of its 1989 R&D total. In the United Kingdom, R&D funding for industrial development—at 10 percent of total—trailed only defense in percentage share. Industrial development accounted for 8 percent of the Japanese total, but just 0.2 percent of the government R&D funding total in the United States. The latter figure—which may be understated relative to other countries as a result of compilation differences—nonetheless reflects longstanding U.S. policy to rely on private sector investment decisions in this area.

Figure 4-15.
Nondefense R&D: foreign spending as a percentage of U.S. spending



See appendix table 4-27. *Science & Engineering Indicators – 1991*

Text table 4-7.
Government R&D support, by socioeconomic objective: 1989

	United States	Japan	West Germany	France	United Kingdom
	Percent				
Total	100.0	100.0	100.0	100.0	100.0
Defense	65.5	9.0	19.0	41.9	55.2
Civil space	7.3	11.1	8.5	8.7	3.8
Advancement of research	3.8	13.8	20.7	17.5	5.8
Health	12.9	4.8	5.2	3.7	6.2
Industrial development	0.2	8.1	19.0	15.0	10.3
Energy	3.9	39.2	9.5	4.0	4.0
Agriculture, forestry, and fishing	1.9	6.5	3.1	4.6	5.5
Other	4.5	7.6	14.9	4.5	9.2

NOTE: Data were adjusted to exclude general university funds for Japan (43 percent of the government-funded R&D total), West Germany (33 percent), France (12 percent), and the United Kingdom (18 percent). See text.

See appendix table 4-30. *Science & Engineering Indicators – 1991*

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[51] Data on the socioeconomic objectives of R&D funding are rarely obtained by special surveys. They generally are extracted in some way from national budgets which already have their own methodology and terminology, and thus are subject to comparability constraints not placed on other types of international R&D data sets. Notably, although each country adheres to the same criteria for distributing their R&D by objective (as outlined in OECD 1981), the actual classification may differ among countries because of differences in the ***primary objective*** of the various funding agents. Note also that these data are of government R&D funds only, which account for widely divergent ***shares*** and ***absolute amounts*** of each country's R&D total.

[52] The shares presented here and in text table 4-7 are adjusted to ***exclude*** general university funds which are reported separately for Japan and European countries. For example, GUF accounted for 18 percent of the government-funded R&D total in the United Kingdom: Unadjusted for GUF, its defense share was 46 percent in 1989. The United States does not have an equivalent GUF category: Funds to the university sector are distributed among the objectives of the Federal agencies that provide the R&D funds. (See appendix table 4-30 for further details.)

[53] For detailed comparisons of academic and academically related research, including GUF estimates, in the United States, United Kingdom, The Netherlands, France, West Germany, and Japan, see Irvine, Martin, and Isard (1990) and NSB (1989), pp. 98-99.

Globalization of R&D

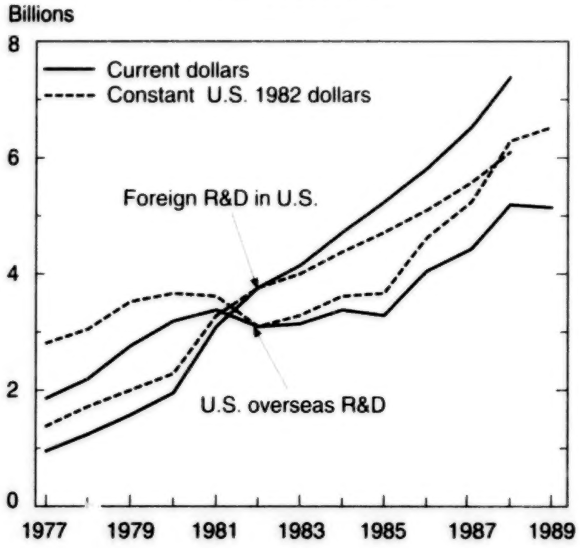
R&D investing has become increasingly global since roughly the mid-seventies. Stiff international competition in research-intensive, or high-technology, products has necessitated many firms' expansion into foreign markets. (See chapter 6, "The Global Market," p. 136.) As a factor in this global market shift, growing development costs and shortening product life cycles have compelled corporate managers to expand overseas research activities so as to tailor products for the specific needs of foreign customers. Thus, much of the R&D undertaken abroad is meant not to displace domestic R&D, but rather to support overseas business growth.[54]

Growth in R&D funds moving both into and out of the United States has been quite strong for the past decade or so. On average, U.S. overseas R&D investments grew by 5.3 percent per year between 1977 and 1989 (in constant dollars). This rate was slightly below that for growth in total U.S. industry R&D funding—5.7 percent annually. And since 1985, the overseas R&D component has grown at six times the rate of industry's domestic funding (11.9 versus 2.1 percent per year): R&D abroad is now equivalent to 9 percent of industry's onshore R&D expenditures. (See figure 4-16.) U.S companies and their foreign subsidiaries in the motor vehicles, machinery (including computers), and drug industries account for the largest shares of this foreign-based R&D activity. Together, they comprised 58 percent of the 1989 overseas performance total. (See appendix table 4-31.) Time series data are not available on which countries receive this U.S. R&D investment.[55]

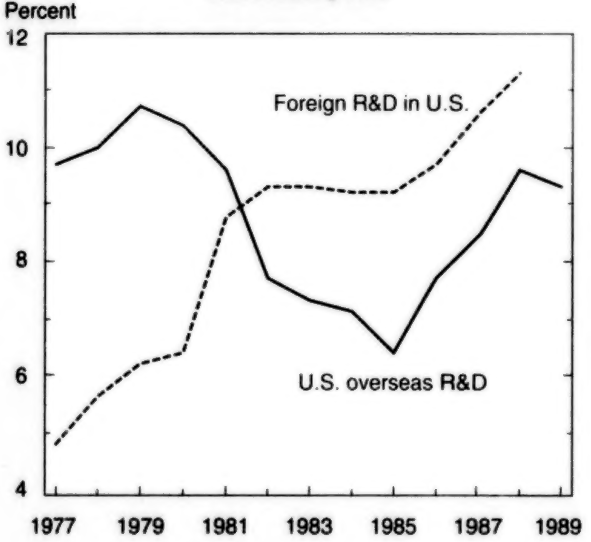
About $6.3 billion was spent on R&D abroad by U.S. companies in 1988. Foreign companies spent about 17 percent more ($7.4 billion) on R&D in the United States. From 1977 to 1988, growth in this foreign-sourced R&D investment averaged 14 percent per year, or more than twice the rate of growth in domestic R&D activities by U.S. companies. As a result, foreign R&D was equivalent to 11 percent of all industry's R&D funding in the United States in 1988, up from its equivalent 5-percent share in 1977. (See figure 4-16.) Foreign funding came primarily from Canada, West Germany, and the United Kingdom; although the R&D flows from other European countries and Japan also increased steadily over the past decade. Foreign-funded research was concentrated in the industrial chemicals, drugs, and electrical equipment industries.[56] (See appendix table 4-32.)

Figure 4-16.
Foreign and U.S. overseas R&D

Total foreign R&D in U.S. and U.S. overseas R&D



As a percentage of U.S. industry R&D



See appendix tables 4-31 and 4-32.

Science & Engineering Indicators – 1991

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[54] Companies consider a myriad of factors before undertaking R&D overseas: Market access and accommodation of local requirements are but two of them. Tax and regulatory policies, as well as the availability of trained researchers and access to new scientific and technological developments in other countries, also influence R&D location decisions. See NSB (forthcoming) and Howells (1990a and 1990b).

[55] See, however, Bloom and Rubinger (1991) for information on U.S. firms' investment in R&D facilities in Japan.

[56] The foreign R&D data reported here come from an annual survey of Foreign Direct Investment in the United States conducted by the Bureau of Economic Analysis. The Bureau reports that the foreign R&D totals are comparable to the U.S. R&D business data published by NSF. Industry-specific comparisons, however, are limited because of differences between the two surveys in industry classifications. (See Quijano 1990.)

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Chapter 5
Academic Research and Development: Financial Resources, Personnel, and Outputs

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Academic Research and Development: Financial Resources, Personnel, and Outputs

HIGHLIGHTS

Funding for Academic R&D

- **The 1980s saw a continuation of a trend, observed over the last several decades, toward an increasing role for academic performers in total U.S. research and development (R&D).** From 1981 to 1991, real growth (in constant 1982 dollars) in academic R&D expenditures averaged 5.5 percent annually. In current dollars, funding over the period rose from just below $7 billion to an estimated $17 billion, increasing from a 9.5-percent share to an 11.3-percent share of total U.S. R&D expenditures. *See p. 116.*

- **Much of this R&D growth occurred between 1985 and 1991 when growth was much stronger for the academic sector than for any other performing sector**, an estimated 44 percent, compared to about 11 percent for federally funded research and development centers and other nonprofit laboratories, 4 percent for industrial laboratories, and about 3 percent for Federal laboratories. *See p. 116.*

- **The Federal share of academic R&D support has continued to decline as industrial and internal university support have been growing more rapidly than that of the Federal Government in recent years.** In 1991, Federal sources provided an estimated 56 percent of academic R&D support, down from 69 percent in 1971. In constant dollars, however, academic R&D financed by Federal support increased by 77.5 percent during this 20-year period. *See p. 117.*

- **After the Federal Government, academic institutions that performed the R&D provided the second largest share of academic R&D support.** From 1971 to 1991, the institutional share grew from 11 percent to an estimated 20 percent of academic R&D expenditures. *See p. 117.*

Facilities and Instrumentation

- **The country's research universities have undertaken large increases in investment in academic R&D facilities and instrumentation during the 1980s.** Total capital expenditures for academic science and engineering (S&E) facilities (plant and fixed equipment) increased during the 1980s at an average annual rate of 6.6 percent in constant 1982 dollars. Expenditures for academic research instrumentation have averaged 9.6 percent annual growth for Federal support and 11.3 percent for non-Federal support since 1983 in constant dollars. The number of instruments available for R&D more than doubled between 1982/3 and 1988/9. *See pp. 121-22.*

The Spreading Base and Geographic Distribution of Academic R&D

- **During the 1980s, a growing number of academic institutions have become major research performers, as evidenced by their sustained volume of real research expenditures.** In 1980, 277 academic institutions reported total R&D spending of at least $1 million (in constant 1988 dollars) in 1,162 of their S&E fields; by 1989, these same institutions reported such volume for 1,575 of their S&E fields. *See p. 124.*

- **Continuing a trend that was evident in the 1970s, the 1980s witnessed a slow but marked shift in the distribution of academic R&D toward the Sun Belt and away from the North, East, and—to a lesser degree—West. The South's share rose to 29 percent** from 26 percent in the early 1980s and 23 percent a decade earlier. Similar patterns exist for Federal and non-Federal R&D funds, and for most major fields. *See p. 124.*

Characteristics of Doctoral Researchers in Academic R&D

- **During the 1980s, the number of academic doctoral researchers increased more rapidly than their total academic employment in every major field.** Total employment increased by 32 percent, from 153,220 in 1979 to 202,208 in 1989. The number with primary responsibility for teaching increased by 25 percent (82,643 to 103,115), while those with primary research responsibility rose by 60 percent (48,517 to 77,455). Concurrently, doctoral scientists and engineers reporting that R&D was their primary *or* secondary responsibility rose by 54 percent, from 100,562 in 1979 to 154,860 in 1989. *See p. 125.*

- **As a group, academic researchers are aging.** In 1973, only 25 percent of academic researchers had earned their Ph.D. degrees more than 15 years earlier; this fraction was 45 percent by 1989. The increasing age of academic researchers tends to reflect both the rising average age of doctoral academics in general and low academic hiring levels. *See p. 128.*

- **Each new cohort of Ph.D.-holders hired into academia tends to be more active in research than the preceding ones and to stay more active through the years.** Between 1979 and 1989, the proportion of all academic doctoral scientists and engineers whose primary or secondary work activity was research rose from 67 to 78 percent. *See p. 128.*

Women and Minorities in Academic R&D

- **The number of doctoral women in academic R&D more than doubled between 1979 and 1989,** increasing faster than either the number of S&E Ph.D. degrees awarded to females or women's overall academic employment. Women in 1989 represented 17 percent of all academic researchers; almost half of female researchers were active in the life sciences. *See p. 126.*
- **Since 1979, increases in research participation for minorities have been stronger than for whites.** But the overall number of minority researchers—particularly of blacks, Hispanics, and Native Americans—remains very low. In 1989, minorities constituted 13 percent of academic doctoral S&E researchers; nearly three-quarters of these were Asians. *See p. 127.*

Support of Academic Research Personnel

- **Despite a decline in the Federal share of academic R&D funding over the past decade, a rising proportion of academic researchers received at least some support from Federal sources:** 53 percent in 1979 versus 59 percent in 1989. Increases were evident for all age groups and most major fields. *See p. 129.*
- **In 1989, a record proportion—28 percent—of the growing number of full time S&E graduate students were supported by research assistantships.** During the eighties, the number of graduate students for whom this mechanism was the primary source of support rose by 60 percent. *See p. 130.*

Outputs of Academic R&D: Scientific Publications and Patents

- **U.S.-based authors continue to account for 36 percent of all publications in a set of about 3,200 major U.S. and international technical journals.** This percentage remained steady through the 1980s. *See pp. 129-30.*
- **Patenting by U.S. universities increased sharply in the 1980s.** More than one-fifth of all patents issued to academic institutions since 1969 were awarded in 1989-90. The 100 major research universities accounted for an increasing share of these patents. *See pp. 130-31.*

Introduction

Chapter Focus

Academic research and development (R&D) is an integral part of the national R&D enterprise. The sector now accounts for an estimated 11.3 percent of national R&D expenditures and almost half of national basic research expenditures. Moreover, the 155,000 doctoral scientists and engineers engaged in academic R&D activities in 1989 comprised almost a third of the U.S. doctoral science and engineering (S&E) workforce.

This chapter addresses the following three principal aspects of academic R&D:

- *Financial resources*—sources of funding, distribution among institutions and disciplines, the Federal Government's funding role, the financing of academic R&D facilities and instrumentation, the spreading base of academic R&D, and its geographic distribution;
- *Doctoral personnel*—characteristics of doctorate-level scientists and engineers employed by academic institutions; and
- *Research outputs*—the academic sector's publications and patents.

Chapter Organization

The chapter opens with a discussion of trends in financial resources provided for academic R&D, including allocation across both institutions and fields, and of the changing importance of various key sources of financial support. Since the Federal Government has been the primary source of support for academic R&D for over half a century, its role is explored in greater detail. New this year is a discussion of the key Federal funding agency for each S&E field and how the importance of that agency to the field has changed over time. Also new this year is a discussion of the indirect cost component of the academic R&D budget based on National Science Foundation (NSF) and National Institutes of Health (NIH) data. The section also includes data on funding trends for two key elements of university infrastructure—facilities and instrumentation.

For the first time in the *Science & Engineering Indicators* series, data are presented about the expansion of the institutional base in which academic R&D is housed: the number of institutions, divisions, and departments that are active in R&D and their funding levels.

The second section of the chapter covers the academic R&D workforce and is limited primarily to scientists and engineers with doctoral degrees, since they are the major participants in academic R&D. (Also, very little data are available on nondoctoral academic research personnel.) Trends in the growth of various disciplines and in the numbers of women and minorities in academic R&D fields are addressed. The chapter presents new information about the changing age structure of academic researchers, the trend toward increased research participation in academia, and the extent of Federal support provided to academic doctoral researchers. Also included is a brief discussion of the number of graduate students involved as research assistants in academic R&D.

The chapter's final section discusses the outputs of academic R&D, specifically the publications in scientific and engineering journals and the patents issued to U.S. universities.

Financial Resources for Academic R&D[1]

This section focuses on the levels and sources of support for R&D activities at U.S. universities and colleges. Beginning with an examination of the role of academic R&D in the context of the national R&D system, it covers R&D funding patterns in terms of funding sources and their distribution among academic institutions and across S&E fields. The role of the Federal Government in supporting R&D at universities and colleges is explored in some detail, including the support provided by certain key agencies to both overall academic R&D and specific S&E fields. Support for academic R&D facilities and instrumentation, particularly the levels of investment made in these during the 1980s, is examined, as are the spreading base and geographic distribution of academic R&D.

Additionally, two highly topical subjects related to the main discussion—Federal reimbursement of indirect costs and the Congressional earmarking of R&D funds—are covered in this section.

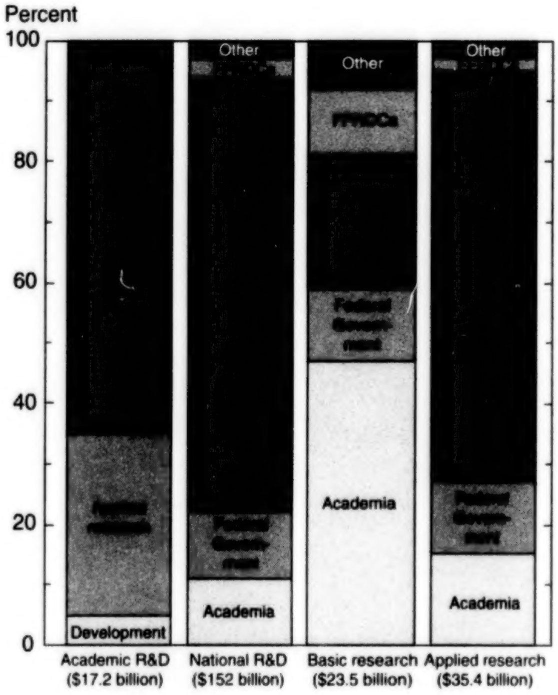
Academic R&D in a National Context[2]

In 1991, an estimated $17.2 billion was spent for R&D at U.S. academic institutions.[3] (See figure 5-1.) This level of expenditure represents a continuing trend, observed over the last several decades, of an increasing role for academic performers in total U.S. R&D. Academic R&D in 1991 made up 11.3 percent of total R&D, compared with 9.4 percent in 1971. During the 1971-91 period, research performed in academic institutions rose from 25.4 percent to an estimated 27.7 percent of total U.S. research expenditures.

In constant 1982 dollars, academic R&D increased an estimated 74.2 percent between 1980 and 1991. R&D growth between 1985 and 1991 was much stronger for the academic sector than for any other performing sector—an estimated 44 percent—compared to about 11 percent for federally funded research and development centers (FFRDCs) and other nonprofit laboratories, 4 percent for industrial laboratories, and about 3 percent for Federal laboratories. However, the rate of growth for academic R&D from 1990 to 1991 is estimated at 2.9 percent, down from the estimated 5.4-percent annual growth rate from 1980 to 1990. As a proportion of the gross national product (GNP), the academic R&D share rose significantly over the past decade, from 0.23 to 0.31 percent.

Academic R&D activities are concentrated at the research (basic and applied) end of the R&D spectrum and include very little development activity.[4] Of 1991 academic R&D expenditures, an estimated 65 percent went for basic research, 30 percent for applied research, and 5 percent for development. (See figure 5-1.)

Figure 5-1.
National and academic R&D expenditures, by character of work and performer: 1991



NOTES: Data are estimates. FFRDCs = federally funded R&D centers.
See appendix tables 5-1 and 5-2.

Science & Engineering Indicators – 1991

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[1] Data in this section come from several different NSF surveys that do not always use comparable definitions or survey methodologies. The three main surveys concerned with academic R&D are (1) the Federal Funds for Research and Development Survey; (2) the Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Survey; and (3) the Scientific and Engineering Expenditures at Universities and Colleges Survey. The results from this last survey, based on data obtained directly from the universities and colleges, do not generally match the data from the other two surveys. For descriptions of the methodologies of these and selected other NSF surveys, see SRS (1987).

[2] This discussion is based on data in SRS (1990c) and unpublished tabulations. For more information on national R&D expenditures, see chapter 4, "National R&D Spending Patterns," pp. 89-93.

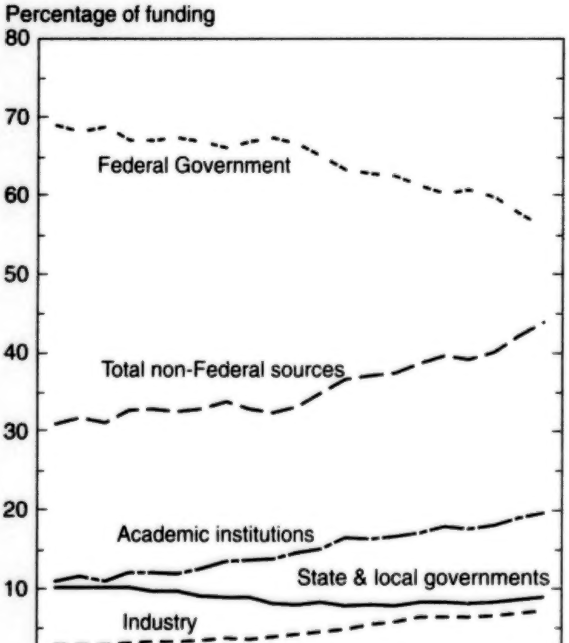
[3] In this section, academic institutions generally comprise institutions of higher education that grant doctorates in science or engineering and/or spend at least $50,000 for separately budgeted R&D. Federally funded research and development centers associated with universities are tallied separately and are examined in greater detail in chapter 4.

[4] Notwithstanding this delineation, "R&D"—rather than just "research"—is used throughout this discussion; this is because almost all of the data collected on academic R&D do not differentiate between the "R" and the "D."

Sources of Funds

The Federal Government provides the majority of funds for academic R&D, but participation by other sectors has been growing more rapidly than that of the Federal Government in recent years. This circumstance has resulted in a decline in the Federal share of academic R&D. (See figure 5-2.) In 1991 the Federal Government provided an estimated 56 percent of the funding for R&D performed in academic institutions, down from 69 percent in 1971. The academic institutions that performed the R&D provided the second largest share of funds. From 1971 to 1991, the institutional share grew from 11 percent to an estimated 20 percent of academic R&D expenditures.[5] Industry increased its share from 3 percent in 1971 to an estimated 7 percent in 1991, while state and local governments and other sources maintained shares of academic R&D funding ranging from 8 to 9 percent for the former and 6 to 8 percent for the latter throughout the 1980s.[6]

Figure 5-2.
Sources of academic R&D funding, by sector



NOTE: Data for 1990 and 1991 are estimates.

See appendix table 5-2. *Science & Engineering Indicators – 1991*

Industry funds for academic R&D grew faster than did funding from any other source during the past two decades. Industry's contribution to academia represented about 1.6 percent of all industry-funded R&D in 1991, compared to 0.7 percent in 1971. The rapid rise in academic *institutions' own R&D funding* increased the ratio of those funds to total institutional operating expenditures from approximately 1.5 percent in 1973 to an estimated 3.0 percent in 1989.

Private and public universities differ in their major sources of R&D support. For public academic institutions, about 11 percent of R&D funding in 1989 came from state and local funds and about 23 percent from institutional funds. Private academic institutions received only 2 percent and 9 percent of their funding, respectively, from these sources. (See appendix table 5-3.) Between 1980 and 1989, the Federal share of support declined for both public and private institutions, dropping from 61 to 53 percent for public institutions and from 79 to 73 percent for private institutions. Both public and private institutions received approximately 7 percent of their R&D support from industry in 1989.

Distribution of R&D Funds Over Academic Institutions

Most academic R&D is concentrated in relatively few of the 3,400 higher education institutions in the United States.[7] In fact, if all such institutions are ranked by their 1989 R&D expenditures, the top 200 ranked institutions account for 96 percent of R&D expenditures. In 1989,

- The top 20 institutions spent 32 percent of total academic R&D funds,
- The top 50 spent 58 percent, and
- The top 100 spent 82 percent.[8]

(See text table 5-1.)

Academic R&D Expenditures by Field and Funding Source[9]

The distribution of Federal and non-Federal funding of academic R&D in 1989 varied by field. (See appendix

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[5] Institutional funds are funds an institution spends on R&D, including unreimbursed indirect costs associated with R&D projects financed by outside organizations and mandatory cost sharing on Federal and other grants. Sources of institutional funds are (1) general-purpose state or local government appropriations, (2) general-purpose grants from industry, (3) tuition and fees, and (4) endowment income. There is some concern that part of the increase in the importance of institutional funds is due to accounting changes.

[6] Other sources of support include grants for R&D from nonprofit organizations and voluntary health agencies as well as all other sources not elsewhere classified.

[7] The Carnegie Foundation for the Advancement of Teaching classified 3,400 degree-granting institutions as higher education institutions in 1987. (See chapter 2, "Classification of Academic Institutions," p. 47, for a brief description of the Carnegie categories.) These higher education institutions include 4-year colleges and universities, 2-year community and junior colleges, and specialized schools such as medical and law schools. Not included are more than 7,000 other postsecondary institutions (secretarial schools, auto repair schools, etc.).

[8] These percentages exclude the Applied Physics Laboratory (APL) at Johns Hopkins University. With an estimated $431 million in total and $422 million in federally financed R&D expenditures in fiscal year 1989, APL performs about two-thirds of the R&D at the university. Although not officially classified as an FFRDC, APL essentially functions as one. Its exclusion therefore provides a better measure of the distribution of *academic* R&D dollars and the ranking of individual institutions.

[9] The data in this section are drawn from NSF's Scientific and Engineering Expenditures at Universities and Colleges Survey. Parallel data by field from NSF's Survey of Federal Obligations to Universities and Colleges do not necessarily match these numbers for a variety of methodological reasons.

Text table 5-1.
Distribution of R&D funds among academic institutions: 1989

Rank	Millions of dollars	Percentage of total
All institutions[1]	14,556	100
Top 10	2,606	18
Top 20	4,612	32
Top 50	8,484	58
Top 100	11,901	82
Top 200	14,023	96

[1] The Applied Physics Laboratory at Johns Hopkins University, with an estimated $431 million in 1989 R&D expenditures, is not included in these totals.

See appendix table 5-4. *Science & Engineering Indicators – 1991*

table 5-5.) For example, the Federal Government supported 65 percent of academic R&D expenditures in the medical sciences, but only 27 percent of academic R&D in the agricultural sciences. This latter figure reflects the traditionally strong role of states in supporting the agricultural sector.

By far, the majority of academic R&D expenditures in 1989 went to the *life sciences*, which accounted for 54 percent of total academic R&D expenditures, 53 percent of Federal academic R&D expenditures, and 55 percent of non-Federal academic R&D expenditures. The next largest block of total academic R&D expenditures was for *engineering*—16 percent in 1989. (See appendix table 5-5.)

Between 1979 and 1989, academic R&D expenditures for all fields combined grew at an average annual rate of 5.6 percent in constant 1982 dollars. (See figure 5-3 for constant dollar expenditures over the decade by field.) From 1988 to 1989, the rate increased to 6.8 percent. Funding for the *computer sciences* grew fastest during the decade, increasing at an average annual rate of 11.4 percent in constant dollars. R&D expenditures for the computer sciences in 1989 were about 3.1 percent of total academic R&D. *Engineering* and the *medical sciences* grew second fastest during the decade, both increasing at an average annual rate of 6.6 percent; for 1988 to 1989, the rates increased to 9.6 and 8.7 percent, respectively.

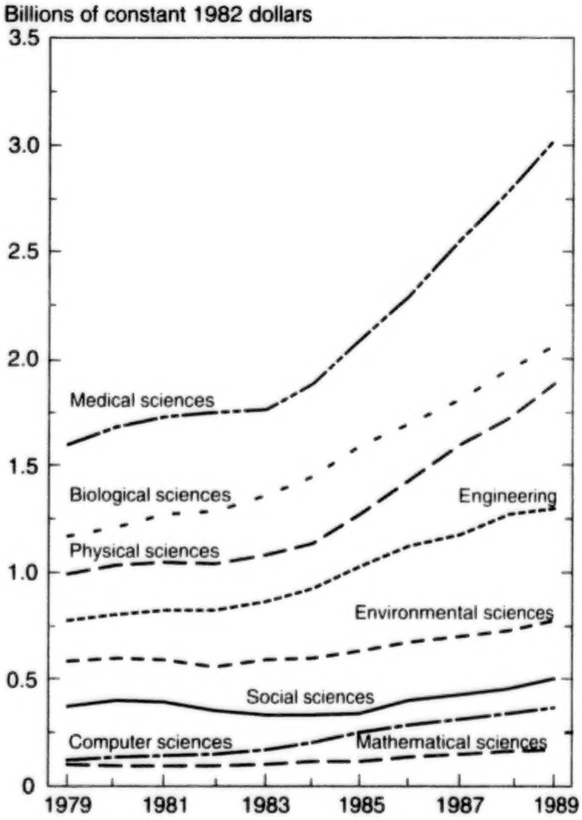
Academic R&D expenditures in the *social sciences*, which averaged annual decreases of 2.5 percent in constant dollars between 1979 and 1984, show increases since 1984. Between 1984 and 1989, funding for the social sciences increased at an average annual rate of 8.7 percent in constant dollars, with the growth rate for 1988 to 1989 estimated at 10.4 percent.

It is noteworthy that the declining Federal share in the support of academic R&D is not limited to specific S&E disciplines. The federally financed fraction of support for each of the S&E fields declined over the past two decades. (See appendix table 5-7.) The most dramatic decline occurred in the social sciences (57 to 33 percent); the smallest decline was in the mathematical and computer sciences (74 to 70 percent). This relative decline also holds for most S&E subfields.

Support of Academic R&D by Federal Agencies[10]

Federal obligations for academic R&D are concentrated in three agencies: NIH, NSF, and the Department of Defense (DOD). Together, these agencies provided about 75 percent of total Federal financing of academic R&D in 1991, up from 66 percent in 1971. (See appendix table 5-8.) NIH was estimated to have provided 47 percent of Federal support for academic R&D in 1991; the NSF share was estimated at 16 percent. DOD, after increasing its share of Federal support from 9 percent in 1977 to just below 17 percent in 1986, declined to an estimated 12-percent share in 1991. During the 1981-91 period, however, the National Aeronautics and Space Administration (NASA), which is estimated to provide less than 6 percent of Federal support, had the highest estimated average annual growth in its funding of academic R&D, 7.7 percent per year (constant 1982 dollars), followed by NIH (4.0 percent) and NSF (3.6 percent).

Figure 5-3.
Academic R&D expenditures, by field



NOTE: See appendix table 4-1 for GNP price deflators used to convert current dollars to constant 1982 dollars.

See appendix table 5-6. *Science & Engineering Indicators – 1991*

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[10] See "Congressional Earmarking to Universities and Colleges," p. 119, for a discussion of an issue related to Federal academic R&D support that engenders considerable debate.

Congressional Earmarking to Universities and Colleges

Academic earmarking—the Congressional practice of providing Federal funds to educational institutions for research facilities or projects without merit-based peer review—is not a new phenomenon. Congress has traditionally earmarked most of the academic research funds from the Department of Agriculture to specific universities and colleges. The lack of an accepted definition for academic earmarking, combined with the difficulty of detecting many earmarked projects because they are either obscured or described vaguely in the legislation providing the funding, makes it difficult to obtain exact figures for either the amount of funds or the number of projects specifically earmarked for universities and colleges.

Despite such problems, several recent efforts have been made to estimate trends in academic earmarking. These estimates indicate that during the past 10 years significant increases have occurred in both the number of earmarked projects and the amount of money directed toward them.

- NSB (1985) reported that between fiscal years (FYs) 1983 and 1985, 15 universities that bypassed the merit review process received over $100 million for research facility construction by appealing directly to Congress. The data showed increases in funding appropriation or authorization from $16.5 to $29.8 to $60.6 million over the 3-year period; the number of projects for which funds were either appropriated or authorized rose from three to four to nine.
- In his recent study of academic earmarking, Savage (1989) defines an earmarked project as "one that would not exist without the intervention of Congress." Using Congressional Research Service estimates for FYs 1980-87 and data collected by the University of California for FYs 1988 and 1989, Savage reports an increase in funds for academic earmarking from about $10 million in 1980 to over $100 million in 1985, to over $200 million in 1989; the number of earmarked projects increased from 7 to 36 to 87 over the same period. These data include earmarks from appropriations bills, supplemental appropriations, and continuing resolutions.
- Cordes (1991) defines earmarking to include (1) projects for which agencies neither requested money nor sponsored merit-based competitions to determine which institutions should get the awards, (2) projects for which an institution had competitively obtained funds in previous years but which would have been discontinued if Congress had not insisted that an award be made, and (3) projects that had been competitively awarded for which Congress had ordered an agency to add a specific amount of money without any review. Based on this definition, Cordes estimated earmarking at about $200 million in FY 1988, slightly under $300 million in both FYs 1989 and 1990, and almost $500 million in FY 1991.
- The Office of Science and Technology Policy (OSTP) recently completed a detailed analysis of earmarking in the 1991 appropriations bills (see OMB 1991a, chapter IV.C, pp. 63-64). In all, 492 earmarks were identified (111 for R&D facilities, 381 for research projects) totaling $810 million($428 million for R&D facilities, $382 million for research projects). These figures, however, are not limited to Congressional earmarking to universities and colleges, but also include earmarks to nonacademic institutions.

Support by Single Agencies. Although the overall dependence of universities and colleges on the Federal Government for their R&D funds has diminished over the past couple of decades, each of the S&E fields has become more dependent on a single agency for its Federal funds than it was in the past. The agency providing the largest share of Federal research funds for each of the seven S&E fields provided a larger fraction of the Federal funds for that field in 1989 than it did in 1971. (See figure 5-4.) This increased reliance on one agency for Federal support also pertains in general to most of the S&E subfields. Only for astronomy, oceanography, the computer sciences, and aerospace engineering did the principal funding agency provide a significantly smaller share of funds in 1989 than during the early(or late) 1970s.

Indirect Costs. One aspect of Federal support of academic R&D that has engendered a great deal of discussion is universities' and colleges' indirect cost recovery from the Federal Government. (See "Indirect Costs of Federally Funded Academic Research," p. 120.) Although indirect cost *rates* at universities and colleges have been increasing during the 1980s, the indirect cost *shares* of the research budgets of NSF and NIH have not increased much, if at all, during this period.[11]

At NSF, the indirect cost share of its academic research budget exhibited a slight decline during this period from a high of 25.3 percent in 1983 to its current level of 24 percent. (See text table 5-2.)

At NIH, from 1983 to 1988 there was a leveling of indirect costs to about 31 percent of the total costs for NIH

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[11] Aside from NSF, few Federal agencies keep detailed data breaking down their R&D awards to universities and colleges into separate budget components, including indirect costs. NIH, although it does not keep detailed budgetary data similar to NSF's, does provide information about the proportion of its funds going to indirect costs. See NIH (1990).

Indirect Costs of Federally Funded Academic Research

Reimbursement of indirect costs, or overhead, as part of the budget for federally funded academic research is a subject that generates considerable discussion among researchers, university administrators, Federal officials, and members of Congress. Indirect costs are all the allowable costs of an academic institution's research that cannot be allocated or directly charged to a research grant or contract. Indirect costs associated with federally funded research at universities and colleges account for several billion dollars of the Federal academic research budget.

There is general agreement that (1) indirect costs are real costs of research and (2) if they were not at least partly recovered, accepting significant amounts of external research funds could put a strain on a university's budget. The Office of Management and Budget's (OMB's) Circular A-21 sets out the rules for specifying the direct and indirect costs of federally funded research and defines the cost pools that may be treated as indirect costs (OMB, 1991b). The circular leaves some flexibility in how various costs may be considered; the variation in schools' indirect cost rates in part reflects that flexibility.

Though administrative overhead costs have been the focal point of concern over rising indirect cost rates, charges for depreciation or use of facilities and equipment were the fastest growing indirect cost component over the last decade. Operation and maintenance costs were the second fastest growing component. One approach might be for these two components to be broken out into a separate indirect cost rate for infrastructure. Growth in such a rate may be easier to explain when it is clearly associated with facilities and equipment for research than when it is submerged in a more loosely defined aggregate.

Many proposals have been offered to contain the growth of indirect cost payments by the Federal Government. These proposals have generally called for limits on either the overall indirect cost rate or on the administrative portions of the rate by setting a uniform rate for all institutions or by setting a ceiling. In May 1991, OMB proposed that reimbursement on Federal research grants for the administrative cost portions of indirect costs be limited to 26 percent of "modified total direct costs." These modified costs are direct costs less equipment costs and subcontracts over a certain size. Similar proposals to cap administrative components of indirect costs have been made before. An interagency task force has been established by OMB to review and revise Circular A-21 in the interests of greater clarity, simplicity, and equity. The task force is expected to conclude its work by the end of 1992.

research grants. The variation during this period was less than half a percentage point. In 1989 the proportion of NIH funds for indirect costs rose slightly to 31.6 percent. Although the NIH indirect cost data are not limited to academic research awards, in 1989 74 percent of NIH's extramural support went to institutions of higher education.

Indirect cost *rates* can rise while the indirect cost *share* of a Federal agency's academic R&D budget can be flat or even falling for such reasons as

- A shift of Federal research funds to institutions with lower indirect cost rates,
- More awards that do not allow the recovery of full indirect costs,
- A larger fraction of direct research costs that are not included in the "modified direct cost base" used for calculating indirect cost payments, and
- More awards that require cost sharing that take the form of a voluntary waiver of some of the indirect costs.

Without much more detailed data than are currently available, it is difficult to determine the extent to which each of these factors affects the behavior of indirect costs.

Academic R&D Facilities and Instrumentation[12]

After an extended period of decreased support for academic R&D infrastructure beginning in the late 1960s, the country's research universities invested heavily in

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[12] Data on facilities and instrumentation are taken primarily from the following sources:

- SRS (1991b)—as used in this survey report, "facilities" refers to capital investment expenditures for S&E research or instruction at those universities and colleges spending $50,000 or more annually on separately budgeted R&D.
- SRS (1988b) and SRS (1990d)—in these survey reports, "facilities" are physical plant, including infrastructure (power), fixed equipment (benches, fume hoods) and nonfixed equipment costing more than $1 million. Information on R&D space is included.
- SRS (1988a), SRS (1991a), and additional unpublished data and analysis tables.

Although terms are defined specifically in each survey, in general, "facilities expenditures"

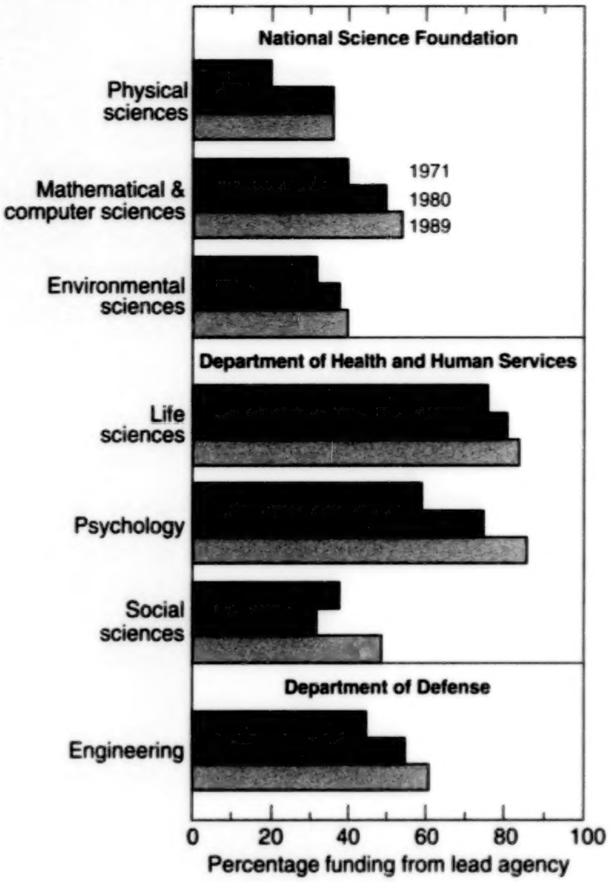
- Are classified as "capital" funds,
- Are fixed items such as buildings,
- Often cost millions of dollars, and
- Are not included within R&D expenditures.

"Equipment" and "instruments" (the terms are used interchangeably) are generally

- Movable,
- Purchased with current funds, and
- Included within R&D expenditures.

Because the categories are not mutually exclusive, some large instrumentation systems could be classified as either facilities or equipment.

Figure 5-4.
Funding provided by current lead Federal R&D funder, by field



See appendix table 5-9. *Science & Engineering Indicators – 1991*

academic R&D facilities and instrumentation during the 1980s. Recent surveys of both facilities and instrumentation indicate that these increases in expenditures have begun to address some of the needs in these areas.

Facilities. In addition to the $15 billion that academic institutions spent for separately budgeted R&D activities in 1989, $2.1 billion was disbursed for capital investment in S&E facilities and fixed equipment to be used for R&D and instruction. (See figure 5-5.) In constant dollars, this amount represented an increase of 2.7 percent over 1988—significantly less than the 9.2-percent constant dollar increase that occurred between 1987 and 1988.

Total capital expenditures for academic S&E facilities (plant and fixed equipment) rose during the 1980s at an average annual rate of 6.6 percent in constant 1982 dollars. Among the S&E fields, engineering enjoyed the highest rate of growth in capital expenditures—an average of 12.0 percent annually in constant 1982 dollars since 1980. The physical sciences field was second with 8.3-percent average annual growth between 1980 and 1989. (See appendix table 5-11.) The lowest growth rate was experienced by psychology, which declined at an average annual rate of 7 percent in constant dollars.

Overall, the proportion of capital funds from non-Federal sources has been increasing—from 74 percent in 1972, to 81 percent in 1980, to just over 90 percent in 1989. Non-Federal sources, which include state and local governments, special bonds, donations, and other sources, grew an average of 7.8 percent a year in constant 1982 dollars between 1980 and 1989; concurrently, Federal spending declined at an average annual rate of 0.7 percent.

The survey data indicate that new facilities construction projects are becoming more expensive: in 1986-87, the cost of new academic R&D space in current dollars was $207 per square foot, compared to $231 per square foot in 1988-89, and an estimated $311 per square foot in 1990-91. (See appendix table 5-12.) Construction outlays for academic research facilities are expected to reach $3.5 billion (in current dollars) in 1990-91, up from $2.5 billion in 1988-89 and $2.1 billion in 1986-87.[13]

When the projects initiated between 1986 and 1989 are completed, they are expected to produce over 20 million square feet of new research space—the equivalent of about 19 percent of existing research space. This new research space is not expected to lead to any significant increase in the total amount of research space, however, but rather will replace obsolete or inadequate space. The new construction projects initiated in 1990-91 are expected to produce about 11 million square feet of new research space.

Text table 5-2.
Indirect cost share of total costs for National Science Foundation (NSF) and National Institutes of Health (NIH) research grants

	NSF	NIH
	—Percent—	
1983	25.3	30.5
1984	24.6	31.2
1985	24.2	31.3
1986	25.1	31.4
1987	24.3	31.3
1988	24.4	31.2
1989	24.0	31.6

NOTES: NSF data include all academic awards (grants and contracts) from its five research directorates—Biological, Behavioral, and Social Sciences; Computer and Information Science and Engineering; Engineering; Geosciences; and Mathematical and Physical Sciences.

NIH data include all extramural research awards as well as all academic awards. In 1989, 74 percent of NIH's extramural support went to institutions of higher education.

SOURCES: National Science Foundation and National Institutes of Health, unpublished tabulations.

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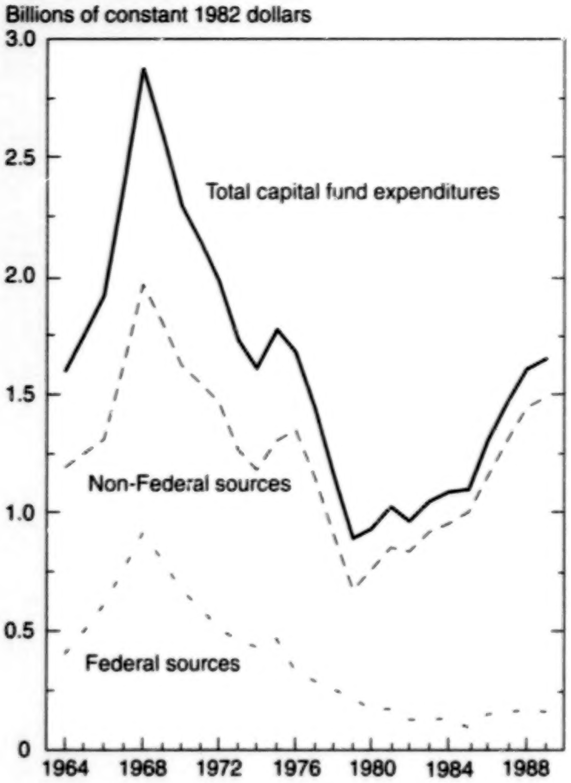
[13] Data are aggregated into 2-year units (1) because some data were only available aggregated for 1988 and 1989 and (2) to increase stability of the estimates. See SRS (1988b) and SRS (1990d).

Figure 5-5.
Federal and non-Federal capital fund expenditures for academic science and engineering



NOTE: See appendix table 4-1 for GNP price deflators used to convert current dollars to constant 1982 dollars.

See appendix table 5-10. *Science & Engineering Indicators – 1991*

More than 85 percent of the current academic research space is concentrated in five S&E fields:

- Biological sciences (22 percent),
- Agricultural sciences (18 percent),
- Medical sciences (17 percent),
- Engineering (15 percent), and
- Physical sciences (14 percent).

Between 40 and 60 percent of the institutions that perform research in these fields reported a need for more research space for work in the discipline. Although the increased facilities funding has been beneficial to the academic research infrastructure, survey results indicate that respondents believe there is still a construction backlog as well as considerable space that needs renovation and repair.

Instrumentation.[14] Current fund expenditures for academic research instrumentation have been growing steadily since 1983 in constant dollars.[15] (See appendix table 5-13.) About 60 to 65 percent of these expenditures were covered by the Federal Government during the 1980s. This percentage varied among individual fields, however, with two fields—the agricultural sciences and the social sciences—receiving considerably less than half of their research equipment funds from the Federal Government. Over the decade, Federal support did not grow as quickly as did non-Federal. Annual growth in Federal support averaged 9.6 percent since 1983, while non-Federal support grew 11.3 percent in constant 1982 dollars.

By field, expenditures for instruments for mathematical sciences, engineering, computer sciences, and physical sciences grew fastest, increasing at average annual rates, in constant 1982 dollars, of between 10 and 15 percent since 1983. Funds for research equipment for the social sciences and psychology grew the slowest, averaging less than 5 percent annual growth since 1983. During the last several years, the rapid growth in equipment expenditures of the mid-1980s has abated slightly. The annual growth rate for total R&D equipment expenditures fell from 6 percent in 1987-88 to 4 percent in 1988-89.

From 1981 through 1989, annual research equipment expenditures comprised 6 to 7 percent of total R&D expenditures, with a slight upward trend in this percentage over the decade. Equipment purchases as a percentage of R&D expenditures were consistently higher than average in the computer sciences, physical sciences, and engineering and consistently lower in the mathematical sciences and social sciences.

Characteristics of Academic R&D Instrumentation. Although the data on annual expenditures for research equipment at universities and colleges provide useful information about spending trends, they indicate little, if anything, about other important characteristics of research instrumentation such as cost, adequacy, and age. Congressional concerns expressed during the late 1970s about the adequacy of research equipment in leading research universities pointed up the need for systematic data on the subject. In response, NSF initiated, with NIH sharing in the financial support, a triennial survey—the National Survey of Academic Research Instruments and Instrumentation Needs—to monitor the state of academic research instrumentation.[16]

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[14] Data used here are limited to funds for research instrumentation and do not include funds for instructional equipment.

[15] Current funds—as opposed to capital funds—are those in the yearly operating budget for ongoing activities. Generally, academic institutions keep separate accounts for current and capital funds.

[16] To date, three cycles of the instrumentation survey have been completed using similar designs and data gathering methods. The first cycle was conducted in 1983-84, the second in 1986-87, and the third in 1989-90. Each of these cycles was conducted in two phases. During the first phase (1983, 1986, 1989), information was collected for the physical sciences, computer sciences, and engineering. During the second phase (1984, 1987, 1990), information was collected for the agricultural, biological, and environmental sciences, with the biological sciences portion of the survey including a separately selected sample of medical schools in addition to the sample of nonmedical universities and colleges that provided data for all the major S&E fields.

Approximately 38 percent of all instrument systems in use in 1988-89 had been acquired in the previous 3 years, a number almost identical to the 37 percent reported for instruments in use in 1985-86.[17] (See appendix table 5-14.) About 25 percent of instrument systems in use in 1982-83 had been retired from research by 1985-86, and about 27 percent of those in use in 1985-86 that were more than 3 years old had been retired from research by 1988-89. As a result of both retirement of older equipment and an increase in the size of the equipment stock, the age distribution of the research instrumentation changed significantly over the course of the three surveys. In 1982-83, 62 percent of the in-use instrument systems were 5 years old or less, and 38 percent were 6 or more years old. By 1988-89, 69 percent of the systems were 5 years old or less.

The survey data show increases in the number of instruments, the aggregate purchase price of instruments, and the mean price per system. (See appendix table 5-15.) The number of in-use academic R&D instrument systems in the fields surveyed increased by about 50 percent between both the 1982-83 to 1985-86 period (36,300 to 53,390) and the 1985-86 to 1988-89 period (53,390 to 78,950). The aggregate purchase price for these instruments in current dollars increased from $1.30 billion in 1982-83 to $2.04 billion in 1985-86 to $3.18 billion in 1988-89. Adjusted for inflation, these increases represent a real net increase of 44 percent between the first two periods and 51 percent between the last two periods. The mean price per in-use instrument system in current dollars increased from $36,000 in 1982-83 to $38,000 in 1985-86 to $40,000 in 1988-89. When adjusted for inflation, however, the average price per system was essentially unchanged during the entire 1982-83 to 1988-89 period.

During the 6 years of the three survey cycles, annual expenditures for both the purchase of research instruments and for the repair and maintenance of existing research instruments increased. (See text table 5-3.) After adjustment for inflation, expenditures for purchasing new or used equipment increased by 48 percent between 1982-83 and 1985-86 and by 11 percent between 1985-86 and 1988-89. Maintenance and repair expenditures increased by 26 percent during the first period and by only 5 percent during the second period. As a result of these expenditure patterns, for every dollar spent on purchasing research equipment, 25 cents was spent on maintenance and repair in 1982-83, 22 cents in 1985-86, and 21 cents in 1988-89.

Text table 5-3.
Annual expenditures for research equipment purchases and for maintenance and repair of existing research equipment

	1982-83	1985-86	1988-89
	—Dollars in millions—		
Purchase of nonexpendable research equipment	400	678	831
Maintenance/repair of existing research equipment	101	149	175
	—Cents—		
Amount spent on maintenance/ repair for each $1 spent on research equipment	25	22	21

SOURCE: Science Resources Studies Division, National Science Foundation, *Academic Research Equipment and Equipment Needs in Selected Science and Engineering Fields: 1989-90,* NSF 91-311 Washington D.C., 1991, and unpublished tabulations.

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The purchase of new equipment during the 1980s appears to have produced beneficial results for many academic departments. Most S&E department heads reported that the overall adequacy of their research equipment either remained about the same (32 percent) or improved (50 percent) over the past 3 years. Over the 6-year period of the surveys, there also was a reduction in the percentages of department heads citing important subject areas where department researchers could not perform critical experiments because necessary equipment was lacking. However, although the proportion decreased from 72 percent in the 1983-84 survey to 62 percent in the 1989-90 survey, it was still well above 50 percent in all fields except the biological sciences.

The Spreading Base of Academic R&D

The number of institutions in which academic R&D is housed continued to expand during the past decade, as reflected in the R&D expenditure patterns of 277 academic institutions which have been surveyed annually by NSF since 1973; together, they have consistently accounted for more than 90 percent of total academic R&D spending.

Each of 26 S&E fields[18] in each of the 277 institutions was examined over a 10-year period to determine its R&D volume for 1980 through 1989. In 1980, these institutions reported *some* R&D expenditures (no matter how small) in a total of 3,621 fields; by 1989, the number of fields had increased by 2.7 percent to 3,717. (See appendix table 5-16.) Median constant dollar spending rose from $392,000 in 1980 to $683,000 in 1989.

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[17] In all three surveys, information about current equipment needs and priorities was obtained with reference to actual survey year. Information about equipment dollar amounts and expenditures refers to the year preceding the survey. Therefore, the data discussed here for the physical sciences, computer sciences, and engineering were collected for 1982, 1985, and 1988; the data for the agricultural, biological, and environmental sciences were collected for 1983, 1986, and 1989. Data from these surveys are thus referred to as 1982-83 data, 1985-86 data, and 1988-89 data (see SRS 1988a and SRS 1991a). Unless otherwise noted, data are for instruments costing from $10,000 to $1 million.

[18] The 26 fields into which NSF categorizes academic R&D expenditures include

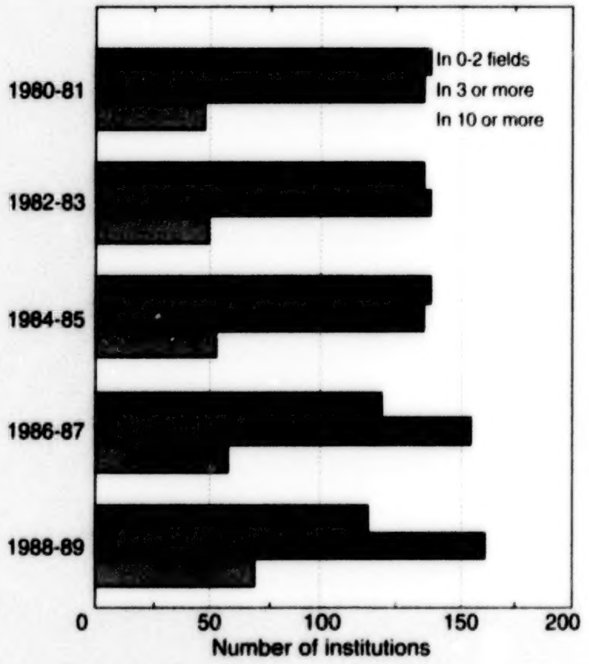
- Six in engineering;
- Four each in the physical, environmental, and life sciences;
- Two in the mathematical and computer sciences;
- Five in the social and behavioral sciences; and
- A category for fields not elsewhere classified, generally referring to interdisciplinary activities.

In 1980, the 277 universities and colleges spent at least $1 million (in constant 1988 dollars) for R&D in 1,162 of their S&E fields. By 1989, the number of such fields had increased by 36 percent to 1,575. (See appendix table 5-16.) Viewed another way, just over half of the 277 institutions (144) had fewer than 3 fields in 1980 that exceeded the $1 million spending threshold; by 1989, this number had declined to 114. Conversely, the number with 10 or more fields above $1 million rose from 46 in 1980 to 69 in 1989. (See figure 5-6.)

Geographic Distribution of Academic R&D

All regions of the country have shared in the growth of academic R&D funds, but not equally so. (See text table 5-4 and figure 5-7.) With new institutions and new departments entering academic R&D, there has been a slow but marked shift in the distribution of academic R&D spending toward the Sun Belt, away from the North, East, and—to a lesser degree—West. The South increased its funding steadily from 23 percent of total in 1973-74 to 26 percent in 1980-81 and 29 percent in 1988-89. (See appendix table 5-18.)

Figure 5-6.
Academic institutions that exceeded $1 million in separately budgeted R&D, by number of S&E fields



NOTES: Data represent 26 science and engineering (S&E) fields in 277 institutions. R&D funding reflects constant 1988 dollars.

See appendix table 5-17. *Science & Engineering Indicators – 1991*

The same general pattern can be observed for Federal and non-Federal R&D funds. (See appendix table 5-19.) The South, once the region with the lowest proportion of Federal funding, in 1988-89 was a close third behind the East and West. In non-Federal funding, the North and South tied for the highest share (28 percent) in 1973-74; by 1988-89, the South had by far the largest proportion—34 percent of the total—and was 15 percentage points ahead of the last-ranked West. (See text table 5-4.)

The same pattern—the South gaining in the share of Federal and total R&D Funds—holds for most S&E fields. Exceptions are mathematics and computer sciences and psychology, which lost share in Federal and gained share in non-Federal funds.

Doctoral Scientists and Engineers Active in Academic R&D

Doctoral academic researchers are those Ph.D.-holding scientists and engineers who are employed by academic institutions and have reported that they are actively engaged in some aspect of R&D (i.e., basic research, applied research, or development).[19] This section

Text table 5-4.
Distribution of academic R&D expenditures, by major region and source of funds

	1973-74	1980-81	1988-89
		Percent	
All sources			
East	28.0	26.5	26.0
West	24.3	24.8	23.1
North	24.1	22.7	21.1
South	23.3	25.7	29.1
Federal			
East	29.9	29.2	28.6
West	26.7	26.7	25.7
North	22.2	21.0	19.6
South	21.0	22.8	25.5
Non-Federal			
East	24.0	21.1	22.2
West	19.1	21.0	19.3
North	28.1	26.1	23.4
South	28.1	31.3	34.3

See appendix table 5-18. *Science & Engineering Indicators – 1991*

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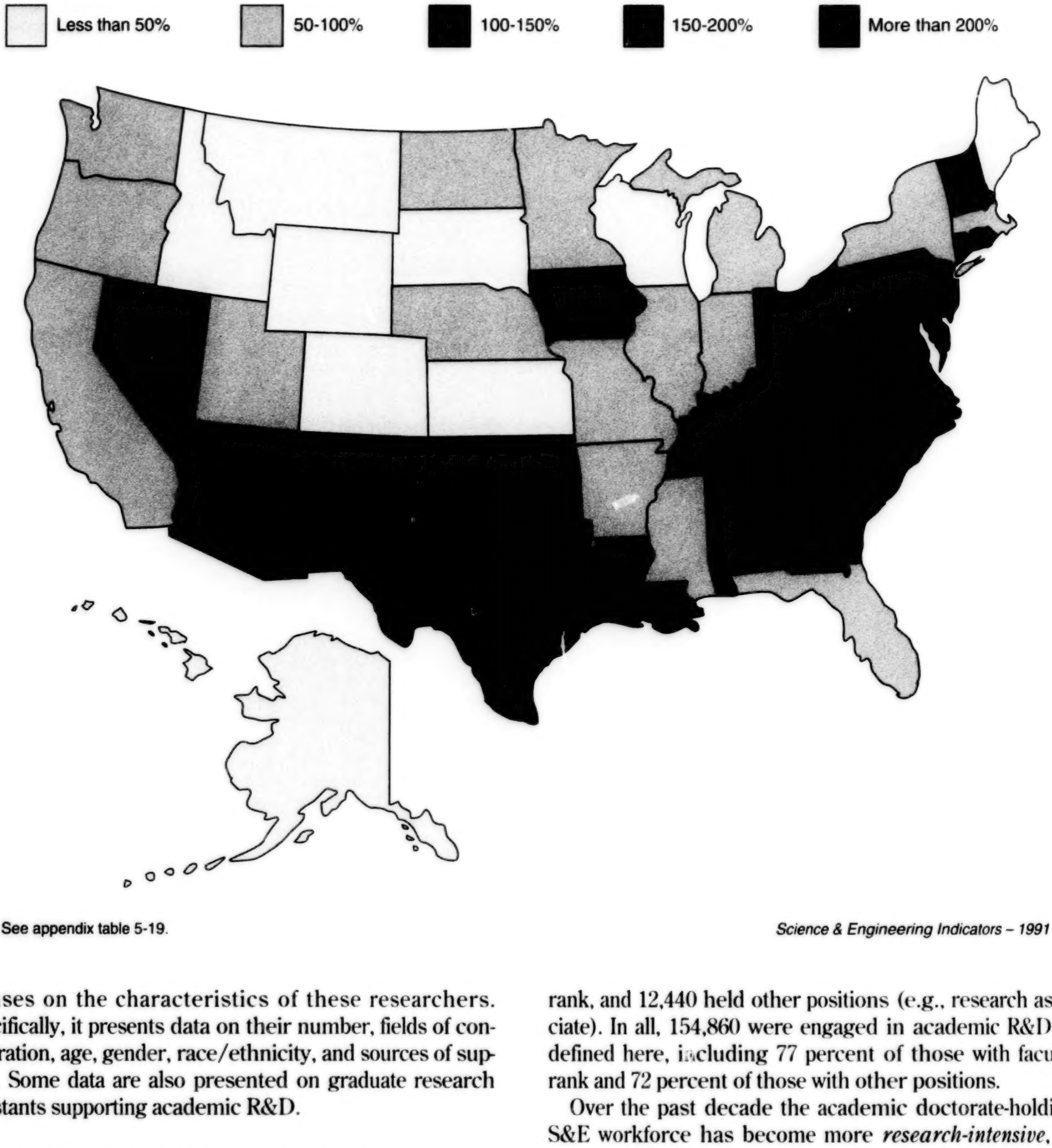
[19] Data on doctoral scientists and engineers are derived from the biennial Survey of Doctorate Recipients conducted for NSF by the National Research Council. In this section, "academic institutions" refer to universities, 4- and 2-year colleges (the latter generally contribute little to R&D activity), and medical schools, as identified by the respondents, but exclude university-managed FFRDCs.

A recent broad assessment of NSF's surveys of scientists and engineers (NRC 1989) has noted certain limitations of the doctorate surveys and has recommended improvements.

Except for some limited data on graduate research assistants, no data are available on nondoctoral academic research personnel.

Figure 5-7.
Real growth in total academic R&D expenditures: 1973/74-1988/89



See appendix table 5-19.

Science & Engineering Indicators – 1991

focuses on the characteristics of these researchers. Specifically, it presents data on their number, fields of concentration, age, gender, race/ethnicity, and sources of support. Some data are also presented on graduate research assistants supporting academic R&D.

Number of Academic Researchers[20]

In 1989, there were 484,809 doctoral scientists and engineers, of whom 202,208 were employed in the academic sector (excluding those in FFRDCs managed by universities or university consortia). (See appendix table 5-20.) Of the doctoral scientists in academia, 189,768 held faculty rank, and 12,440 held other positions (e.g., research associate). In all, 154,860 were engaged in academic R&D as defined here, including 77 percent of those with faculty rank and 72 percent of those with other positions.

Over the past decade the academic doctorate-holding S&E workforce has become more *research-intensive*, as measured by the proportion of those reporting some research activity. Between 1979 and 1989, the number of doctoral scientists and engineers employed in academia increased by 32 percent—from 153,285 to 202,208—but the number of doctoral academic S&E researchers increased by 54 percent—from 100,562 to 154,860. Consequently, the proportion of S&E Ph.D.-holders who reported some research activity rose from 66 percent in 1979 to 77 percent in 1989.

By field, the sharpest *gain* over the decade in research activity was experienced by the social sciences. In 1979,

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[20] Number of academic researchers was determined based on responses to a survey question on primary and secondary work activity. Researchers are defined as respondents who indicate that research is their primary or secondary responsibility.

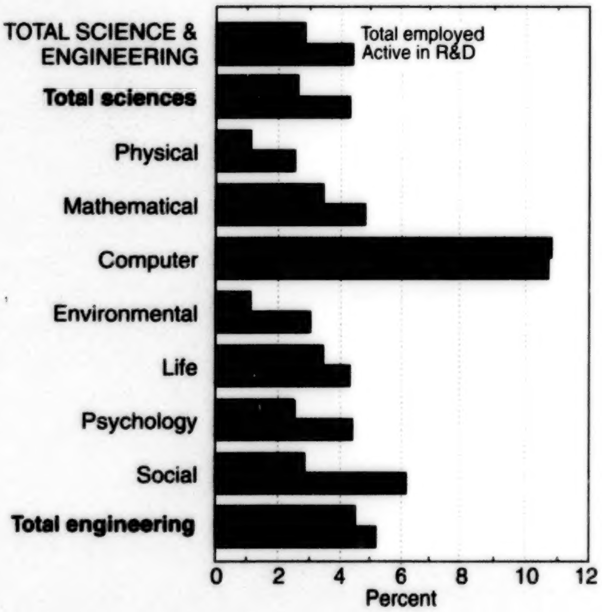
53 percent of all social scientists were involved in research; by 1989, this fraction was 74 percent. The highest *level* of research activity (89 percent) was in the environmental sciences. (See appendix table 5-20.)

Academic Researchers by Field

The field composition of the academic research workforce underwent some changes in the past decade. Life sciences researchers remained the largest group, maintaining their 36-percent share of the S&E total. The number of researchers in the physical sciences grew more slowly than that in other fields—about 2 percent annually, compared with more than 4 percent for all the sciences and more than 5 percent for engineering. (See figure 5-8.) Consequently, the physical sciences declined from 15.4 percent to 12.8 percent of all investigators. Engineering increased its share of total S&E researchers from 10.6 to 11.5 percent, and the social sciences (which gained Ph.D.-level researchers more rapidly than did any other broad field—see "Number of Academic Researchers," p. 125) increased from a 14.9-percent share to a 17.6-percent share. The greatest increase (176 percent over the decade) was registered for researchers in the computer sciences. This increase was from a small base, however, and the overall computer sciences total still represents less than 3 percent of all academic S&E researchers.

The increase in researchers substantially exceeded the increase in S&E employment in each major field. Consequently, between 1979 and 1989 the rate of participation in academic R&D increased in all major fields, rising from 77 to 83 percent for engineering, and from 65 to 76 percent for the sciences. (See appendix table 5-20.)

Figure 5-8.
Annual growth rates of employed doctoral scientists and engineers and those active in academic R&D, by field: 1979-89



NOTE: R&D includes both primary and secondary work responsibility.

See appendix table 5-20. *Science & Engineering Indicators – 1991*

Women in Academic R&D

The overall academic employment of women Ph.D.-holders in S&E almost doubled between 1979 and 1989, jumping from 19,196 to 36,610. Over the same period, the number of women active in R&D more than doubled, increasing from 11,192 to 26,746. (See appendix table 5-21.) Because of this high rate of increase—albeit from a relatively small base—by 1989, women represented 17 percent of all academic researchers, up from 11 percent a decade earlier. (See text table 5-5.) The proportion of female researchers remained roughly in line with the increased percentage of female doctoral scientists and engineers in academic employment.

Almost half of all women doctoral researchers were active in the life sciences. Relatively large proportions of women, compared to men, were also found in the social sciences and psychology. These three areas accounted for 83 percent of all women researchers in 1989, compared to 58 percent of all men. (See figure 5-9.)

Minorities in Academic R&D

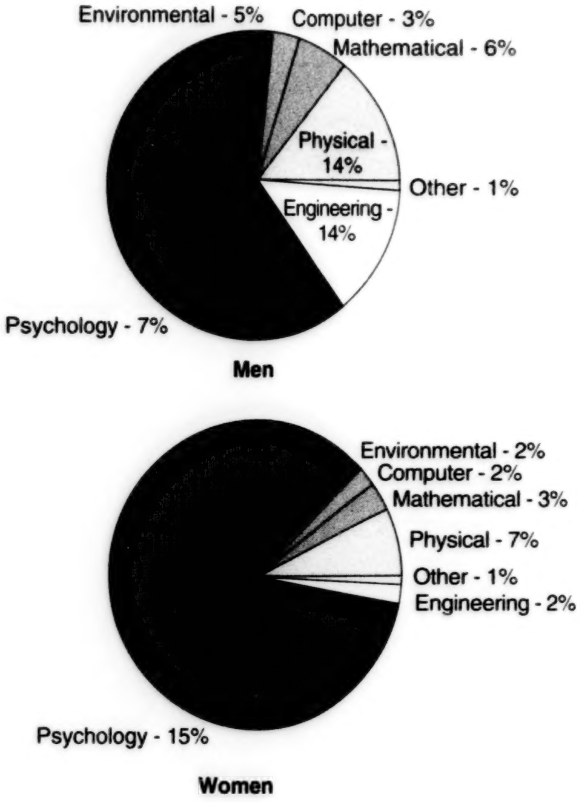
The number of minority Ph.D.-holders—blacks, Asians, Native Americans, and Hispanics—among academic scientists and engineers remained relatively small in 1989 (23,999), as did their number among academic researchers (20,138). (See appendix table 5-21.) Asians continued to predominate among racial/ethnic groups, comprising 68 percent of all minorities employed in academia and 73 percent of the minority researchers.

Text table 5-5.
Women doctorate-holders in academic employment and in academic R&D, by field

	In academic employment		In academic R&D	
	1979	1989	1979	1989
	Percent			
Total science and engineering	12.5	18.1	11.1	17.3
Total sciences	13.7	19.9	12.3	19.1
Physical sciences	6.7	9.5	5.7	9.0
Mathematical sciences	7.4	10.1	6.1	8.8
Computer sciences	5.1	10.3	4.7	10.7
Environmental sciences	5.6	9.5	5.1	9.6
Life sciences	16.1	23.8	15.3	23.1
Psychology	22.1	33.0	20.7	32.0
Social sciences	14.4	19.7	13.2	19.8
Total engineering	1.0	2.8	1.1	3.1

See appendix table 5-21. *Science & Engineering Indicators – 1991*

Figure 5-9.
Distribution of doctoral academic science and engineering researchers, by gender and field: 1989



See appendix table 5-21. *Science & Engineering Indicators – 1991*

Although the absolute numbers of minority doctorate S&E researchers remained low, particularly for non-Asians, there were much stronger proportional gains over the decade for minorities—regardless of race/ethnicity—than for whites. The increase in minority doctoral employment from 1979 to 1989 exceeded 70 percent; that of researchers exceeded 90 percent. For specific fields, the gains were much greater: environmental sciences, 144 percent; engineering and psychology, 115 percent each; mathematics and computer science, 96 percent. (See text table 5-6.) As a result, minorities in 1989 comprised 11.9 percent of total academic S&E doctorate-holders (up from 9.2 percent in 1979) and 13.1 percent of researchers (up from 10.5 percent a decade earlier).

About one-third of all minority researchers were in the life sciences in 1989; this proportion was similar to that of whites. Otherwise, field concentrations vary by race/ethnicity. (See text table 5-7.) Asians disproportionately favor engineering and the mathematical and computer sciences compared to whites. Blacks and Hispanics disproportionately favor the social sciences. (The numbers for Native Americans in the sample survey are too small to allow for meaningful breakdowns.)

Black and Hispanic Ph.D.-holders experienced substantial percentage increases from 1979 to 1989 in both academic employment and academic R&D. (See text table 5-6.) For both doctoral blacks and Hispanics, the numbers employed in academic positions almost doubled. The numbers involved in R&D increased even more rapidly, rising by 137 percent for blacks and 151 percent for Hispanics. The number of Native Americans remained exceedingly low.

Text table 5-6.
Percentage change in minority participation in academic R&D and total doctoral employment, by field and race/ethnicity: 1979-89

	White	Black	Asian	Native American	Hispanic	All minorities
	Percent					
Academic R&D employment						
Total science and engineering	49.9	137.3	79.0	46.6	150.9	91.8
Physical sciences	24.1	225.5	29.4	*	136.1	53.4
Mathematical and computer sciences	56.5	125.5	117.8	*	145.0	123.9
Environmental sciences	56.0	*	110.6	*	210.7	147.5
Life sciences	51.7	93.8	60.0	43.5	93.3	66.9
Psychology	49.3	130.9	326.5	-13.2	183.3	171.7
Social sciences	75.9	115.1	121.4	50.8	311.1	141.9
Engineering	56.6	*	121.8	*	173.7	130.8
Total Ph.D. employment						
Total science and engineering	28.3	91.7	64.8	44.9	92.8	71.8
Physical sciences	8.4	179.2	21.5	*	50.7	35.5
Mathematical and computer sciences	36.0	32.0	100.2	*	106.8	95.6
Environmental sciences	35.7	*	117.6	*	171.8	143.5
Life sciences	37.6	77.2	57.9	73.9	74.6	62.4
Psychology	25.4	87.0	115.5	15.8	285.1	114.6
Social sciences	29.0	82.1	45.2	58.9	168.3	69.8
Engineering	47.4	*	125.2	*	45.7	115.4

* = too few cases to estimate

See appendix table 5-21. *Science & Engineering Indicators – 1991*

This employment growth among minorities, however, came from small numerical bases. Despite these steep relative increases, only 3,299 black S&E Ph.D.-holders were employed in academia in 1989 (1.6 percent of total, up from 1.1 percent a decade earlier) and only 3,893 Hispanics (1.9 percent, up from 1.3 percent in 1979). Among researchers, corresponding percentages were 1.3 percent for blacks (from 0.9 percent in 1979) and 2.0 percent for Hispanics (1.2 percent in 1979).

Changing Age Structure of Academic Researchers

The average age of academic researchers increased in the past decade, continuing a trend that began in the early 1970s. The median age of academic researchers rose from 38.7 years in 1973 to 39.7 years in 1979; it was 43.8 years in 1989.

Put another way, in 1973 only 25 percent of academic researchers had earned their Ph.D. degrees more than 15 years earlier; this fraction had risen to 28 percent by 1979 and to 45 percent by 1989. Conversely, "young" researchers (those who had earned their Ph.D. degrees within 7 years of the survey date) comprised 47 percent of the total in 1973, 36 percent in 1979, and only 28 percent in 1989. (See figure 5-10.)

The increase in mean age was most pronounced in the physical sciences and least pronounced in the life sciences. In the physical sciences, the proportion of researchers who had earned their doctorates more than 15 years ago increased from 25 percent in 1973 to 55 percent in 1989. In the life sciences, the change was from 30 percent in 1973 to 41 percent in 1989. (See appendix table 5-22.) The increasing age of academic researchers mirrors (1) the rising average age of doctoral academics in general, due to the large numbers of the Ph.D.-holding scientists and engineers hired during the 1960s and (2) the lower academic hiring levels since the mid-1970s.

Increased Research Participation

A robust trend, evident over the past decade, shows increasing research participation across all age groups. (See figure 5-11.) Between 1979 and 1989, research participation for all doctoral scientists and engineers rose from 66.5 to 77.7 percent of total. This change was more pronounced for younger Ph.D.-holders, but was not limited to them. (See appendix table 5-23.)

For example, in 1979, 70 percent of all academic scientists and engineers within 7 years of receipt of their Ph.D. degrees were engaged in research. The percentage increased for the subsequent cohorts and reached 88 percent in 1989. This upward trend appears to be sustained as successive Ph.D. cohorts have aged. The rate of research participation declines with increasing age, but this decline was less in recent years than in the past. For example, research participation of those more than 15 years beyond the Ph.D. degree rose from 63 percent in 1979 to 72 percent in 1989. All major fields contributed to this increase. (See appendix table 5-23.)

Text table 5-7.
Distribution of doctoral academic science and engineering researchers, by field and race/ethnicity: 1989

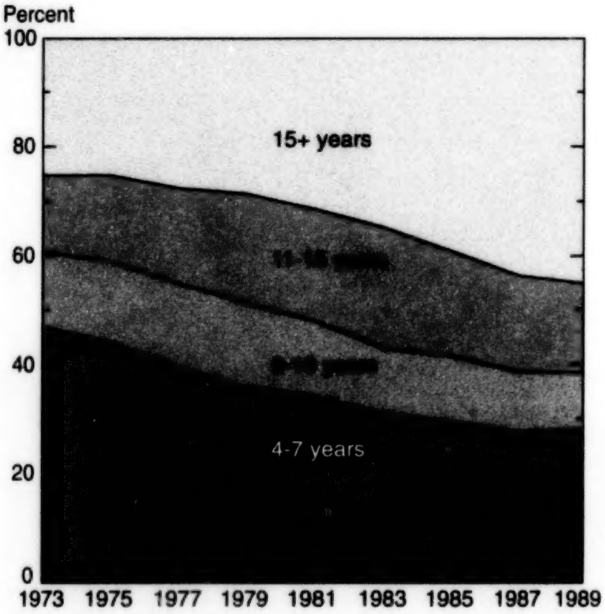
	White	Black	Asian	Native American	Hispanic
	Percent				
Total science and engineering	100.0	100.0	100.0	100.0	100.0
Physical sciences	12.6	14.9	13.12	2.5	13.7
Math/computer sciences	8.4	5.6	11.2	9.3	10.2
Environmental sciences	4.5	1.1	2.3	*	5.5
Life sciences	36.4	32.1	34.5	21.9	31.9
Psychology	8.7	10.6	2.0	10.9	2.7
Social sciences	17.9	26.3	12.4	29.5	22.3
Engineering	10.4	5.5	22.4	*	11.5

* = too few cases to estimate

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

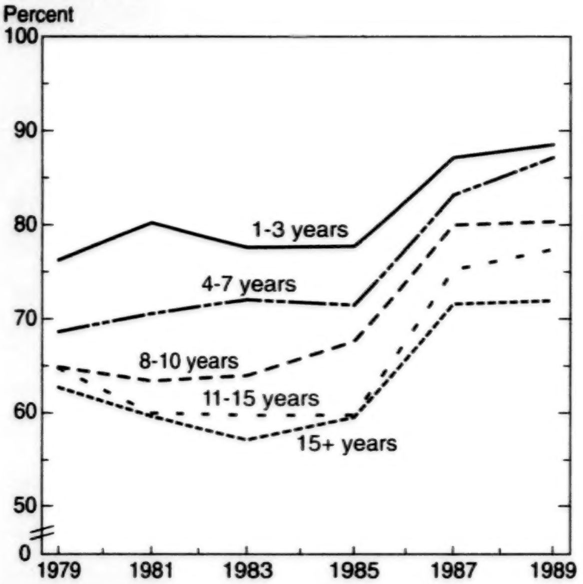
Science & Engineering Indicators – 1991

Figure 5-10.
Age distribution of science and engineering researchers, by years since Ph.D. award



See appendix table 5-22. *Science & Engineering Indicators – 1991*

Figure 5-11.
Academic scientists and engineers active in research, by years since Ph.D. award



See appendix table 5-23. *Science & Engineering Indicators – 1991*

Federal Support of Academic S&E Researchers

Although the Federal Government's *share* of academic R&D funding has declined from 67 percent in 1979 to about 60 percent in 1989, a rising proportion of all academic researchers reported receiving at least some Federal support for their work. Increases occurred for all age groups and all major fields except the social sciences, which essentially maintained their 1979 level of Federal support. (See figure 5-12.)

The proportion of all S&E academic researchers with Federal Government support increased from 53 percent in 1979 to 59 percent in 1989. (See appendix table 5-24.) Between 65 and 75 percent of researchers in the physical, environmental, and life sciences and in engineering reported funding from a U.S. Government agency. These proportions were up from between 55 and 65 percent in 1979. Although only about 42 percent of those in the mathematical and computer sciences reported such support, this constitutes an increase from 28 percent a decade ago in these fields. The proportion of researchers in the social and behavioral sciences reporting Federal support remained unchanged. (See "Graduate Students in Academic R&D,"p. 130, for related information on Federal support of academic researchers.)

Rising Expenditures per Academic Researcher

Academic R&D expenditures rose by 71 percent between 1979 and 1989. Over the same period, the number of academic doctoral researchers rose 54 percent. Correspondingly, inflation-adjusted spending per academic Ph.D.-level researcher also increased: up by 12 percent, from $82,870 to $92,890. The increased trend in spending per researcher is similar to a rise in education and related spending (in constant dollars) per student.

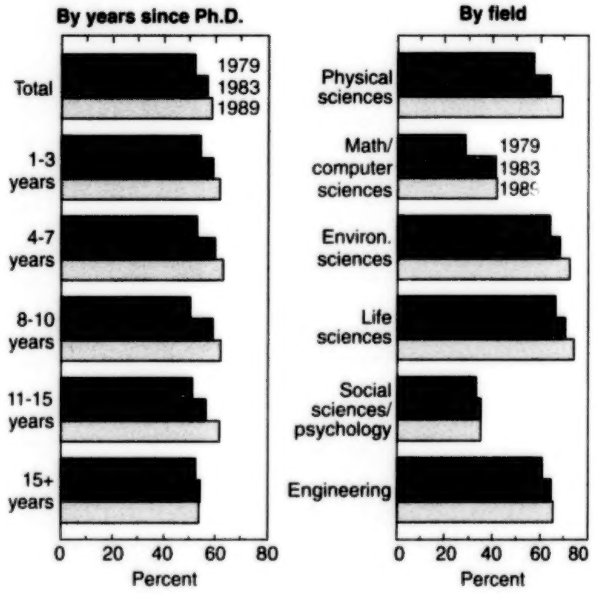
Outputs of Academic R&D: Scientific Publications and Patents

The primary output of university research is new knowledge, which is difficult to conceptualize and measure. An imperfect measure of knowledge, publication counts, is reported here; these counts are based on a fixed set of prominent U.S. and foreign journals.[21] Another indicator discussed in this section is patents awarded to U.S. universities.[22]

World Literature in Key Journals

U.S. Share. U.S. academic institutions continue to produce a substantial share of the world's new S&E knowledge. In 1987, publications of authors at U.S. institutions accounted for 36 percent of world publications in

Figure 5-12.
Academic science and engineering doctoral researchers who reported U.S. Government support



See appendix table 5-24. *Science & Engineering Indicators – 1991*

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[21] The publication counts data used in this section do not measure total world output volume. Instead, they are based on roughly 3,200 technical journals tracked by the Institute of Scientific Information in Philadelphia. It is unclear what share of the total world S&E publications this set of journals represents. Data before 1981 were based on a smaller set of journals, and discontinuities in some trends at that time probably are due to this change.

[22] See chapter 6, "Patented Inventions," p. 147, for a discussion of the limitations of patents data.

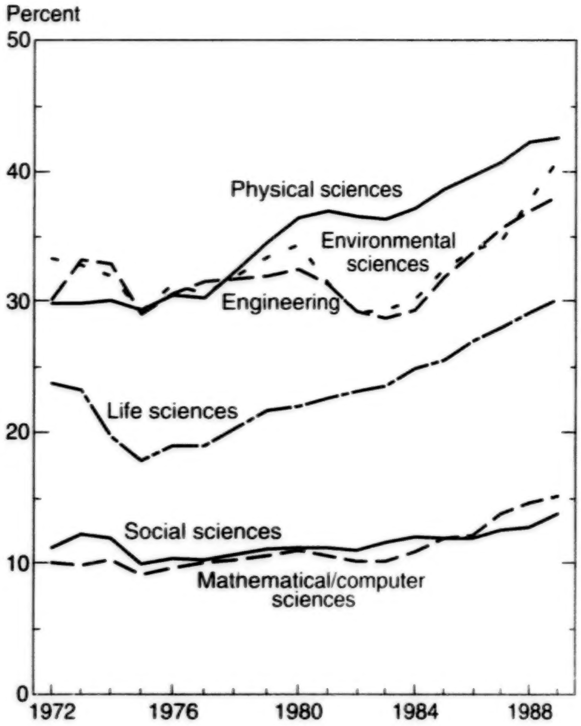
Graduate Students in Academic R&D

In 1989, a record proportion—28 percent—of the growing number of full-time S&E graduate students was supported by research assistantships. (See figure 5-13.) Between 1979 and 1989, the *total number* of full-time S&E graduate students increased 23 percent (from 233,089 to 286,619) while *the number whose primary source of support* was a research assistantship rose by 61 percent (from 49,118 to 79,151). As a result, the percentage of all full-time S&E graduate students supported by research assistantships increased from 21 percent in 1979 to 28 percent in 1989.

Since 1972, the Federal Government has provided research assistantships to an increasing number—but roughly stable proportion—of all full-time graduate students (about 38,000 or 13 percent in 1989). However, both the number and proportion of non-federally supported research assistantships have increased over the period. This increase was particularly notable during the 1980s: The number of non-federally supported research assistantships increased from 21,000 in 1979 to 41,000 in 1989, or from 9 to 14 percent of all full-time S&E graduate students. (See appendix table 5-25.)

The physical and environmental sciences and engineering have the highest proportions of graduate students with research assistantships (between 38 and 43 percent), followed by the life sciences (30 percent). These four areas also experienced the strongest 1979-89 increases in proportions of students supported. In the mathematical and computer sciences, and in psychology and the social sciences, 20 percent or fewer of graduate students had research assistantships, and increases in the proportions so supported were low. (See appendix table 5-25; for more information on graduate student support, see chapter 2, "Support of S&E Graduate Students," p. 57.)

Figure 5-13.
Full-time science and engineering graduate students with research assistantships, by field



NOTE: Data for 1978 are estimated.

See appendix table 5-25. *Science & Engineering Indicators – 1991*

S&E. This figure has been steady since 1981, following a modest decline in the 1970s. (See appendix table 5-26.)

In all fields, the U.S. share of world publications exceeds that of any other country. In 1987, the United States produced

- 22 percent of the world literature in chemistry,
- 30 percent of physics publications, and
- Between 37 and 43 percent of the literature in the other major fields.

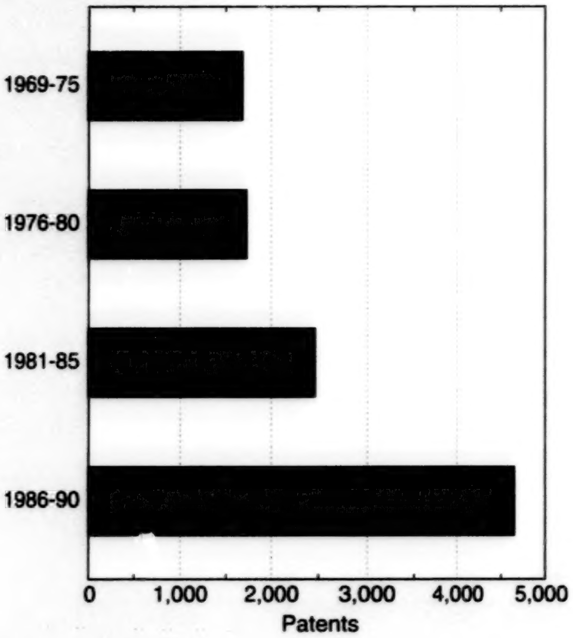
Not all fields have maintained their share of the world's production since 1981, although shifts through 1987 have not exceeded 3 percentage points. Since 1981, the U.S. share of papers in this set of journals has been steady in earth and space sciences; increased in chemistry, physics, and mathematics; and declined in the biomedical and biological sciences and in engineering and technology. (See appendix table 5-26.)

Foreign Country Shares. The United States continues to dominate the publications output in the roughly 3,200 journals covered here. Contributions from U.S.-based authors accounted for 36 percent of the total in 1987; authors in all European Community countries together accounted for another 26 percent. The United Kingdom, West and East Germany (combined), the USSR, and Japan each accounted for 7 to 8 percent; France for 5 percent; and Canada for 4 percent. (See appendix table 5-27 and figure O-18 in Overview.)

Patents Awarded to U.S. Universities

The recent marked increase in university patenting is an indicator of the expanding role played by academic R&D in technology development. The number of patents awarded to U.S. universities increased sharply during the 1980s compared to the 1970s. (See figure 5-14.) This increase was due in part to a 1980 change in U.S. patent

Figure 5-14.
Patents granted to U.S. universities and colleges



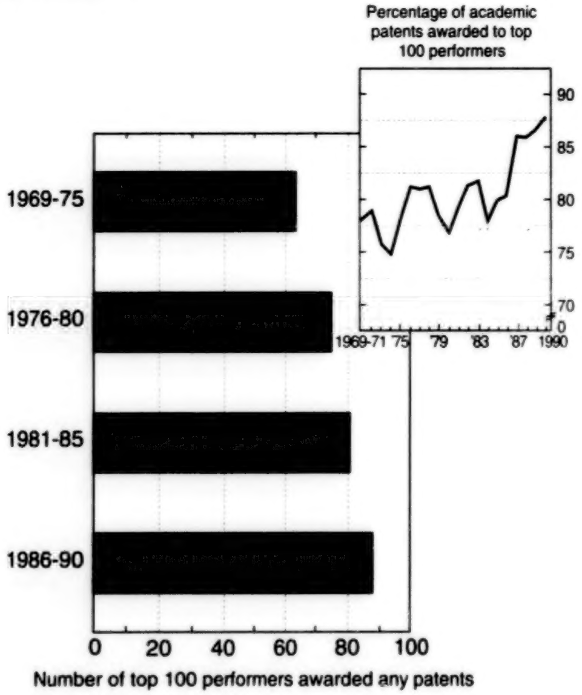
See appendix table 5-28. *Science & Engineering Indicators – 1991*

law that allows academic institutions and small businesses to retain title to inventions resulting from federally supported R&D. In 1990, U.S. universities received 2.4 percent of all U.S. origin patents, up from 1.0 percent a decade earlier.

University patenting increased particularly rapidly during the second half of the 1980s. In fact, 22 percent of all patents issued to U.S. academic institutions since 1969 were awarded in 1989-90. The strongest relative growth occurred in health- and biomedical-related areas, which rose from 12 percent of all academic patents in the early 1970s to 24 percent in the late 1980s. Chemistry (including instruments and processes) also experienced a relative growth spurt, rising from 23 to 30 percent over the same period. Concurrently, areas of electrical- and electronic-related technologies (including data and information processing) dropped from 24 to 16 percent of total academic patents. (See appendix table 5-28.)

The largest research universities account for a large and growing share of all academic patents. Among the 100 largest research universities, only 64 were awarded *any* patents during the 1969-75 period; 89 received patents during 1986-90. (See figure 5-15.) Over the same period, patents awarded to the 100 largest research universities rose from below 75 percent of all academic patents to about 85 percent. (See figure 5-15.)

Figure 5-15.
Patents awarded to top 100 academic research performers



NOTE: Data are based on 1987 R&D expenditures.
See appendix table 5-29. *Science & Engineering Indicators – 1991*

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Chapter 6
Technology and Global Competitiveness

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Technology and Global Competitiveness

HIGHLIGHTS

The Global Markets for U.S. Technology

- **During the 1980s, the United States was consistently the leading supplier of high-tech products in the global marketplace.** However, its lead position declined from a 40-percent share in 1980 to a 37-percent share in 1988. Japan and, to a lesser extent, the United Kingdom increased their global market shares during this period. *See p. 136.*

- **The market competitiveness of U.S. high-tech industries varies by industry.** Of the seven industries that form the high-tech grouping, three U.S. industries—those producing scientific instruments, drugs and medicines, and aircraft—gained global market share during the 1980s. Estimates for 1989-90 show only the instruments industry continuing to gain market share. *See p. 137.*

- **Demand for high-tech products in the home markets of all industrialized countries was increasingly met by foreign suppliers during the eighties.** Import penetration of U.S. high-tech markets was deepest in the computer industry. Japan is still the most self-reliant among the major industrialized countries, followed by the United States. *See p. 138.*

- **During the 1980s, the United States maintained a consistent trade surplus in high-tech manufactures and ran consistent deficits in other manufactures.** The size of this surplus is declining, however: The U.S. 1988 trade surplus in high-tech manufactures was half the value of the 1980 trade surplus. *See p. 140.*

Industrial R&D

- **In all industrialized countries, the industrial sector is the leading performer of R&D.** Except for France, the share of national R&D performed in the industrial sector of these countries grew. Japan and West Germany showed the largest shifts to the industrial sector between 1975 and 1988. *See p. 142.*

- **Private industry is the source of 50 percent of all funds spent for R&D in the United States.** In 1988, Japan and West Germany had considerably larger shares of their national R&D coming from private sources, 70 and 63 percent, respectively. *See p. 143.*

- **U.S. expenditures for industrial R&D nearly tripled during the 1980s in current dollars.** However, the rate of growth slowed considerably during 1984-89. In inflation-adjusted dollars, 1989 industrial R&D expenditures declined for the first time since 1975. Estimates for 1990 and 1991 show this decline continuing. *See p. 143.*

- **During the early 1980s, a renewed emphasis on defense spending led Federal funding of industrial R&D to grow at a faster rate than private funding, reversing the pattern set during the two previous decades.** Since 1987, however, the trend has reverted to the earlier pattern, with private financing again outpacing Federal support. *See p. 144.*

- **Company-financed R&D performed outside the United States increased but at a slower pace than that performed domestically during the first half of the 1980s; it increased at a faster rate during the late eighties.** U.S. chemical and transportation industries had the highest levels of R&D performed overseas. *See p. 146.*

Patented Inventions

- **The number of U.S. patents granted to Americans has reversed its decline and has been increasing since 1983.** Foreign patenting trends in the United States generally followed the U.S. trend, although the number of foreign-origin patents granted declined somewhat slower during 1976-83 and increased somewhat faster after 1983. *See p. 147.*

- **Foreign patenting in the United States is highly concentrated by country of origin.** Inventors from the European Community and Japan account for 80 percent of all foreign-origin U.S. patents. Newly industrialized countries, in particular Taiwan and South Korea, dramatically increased their patent activity in the United States during the last half of the 1980s. *See p. 147.*

- **The patenting emphases of U.S. and Japanese inventors are reversed for many technology fields.** Japanese inventors patent primarily in photocopying, photography, dynamic information storage and retrieval, television, and motor vehicles. U.S. inventors tend to be least active in these fields, but emphasize biochemistry, petroleum, and communication devices—the first two of which are least emphasized classes for the Japanese. *See p. 150.*

- **Americans actively patent their inventions around the world.** In 1989, countries in which U.S. inventors received more patents than other foreign inventors included Japan, West Germany, the United Kingdom, Mexico, Brazil, and India. *See p. 150.*

Industrial Use of Technology

- **Seven out of ten U.S. establishments surveyed use at least one advanced technology in their manufacturing operations.** Larger plants and those producing higher priced products are more likely to use advanced technologies. *See p. 154.*

- **The most commonly used advanced technology in U.S. manufacturing is the numerically controlled machine; this is followed closely by computer-aided design and engineering technology**. *See p. 155.*

Small High-Tech Business

- **High-tech business startups declined sharply in the second half of the 1980s, following tremendous growth during 1975-84.** Companies involved in advanced materials and photonics and optics fields exhibited relative share growth during the latter half of the eighties. *See p. 157.*
- **Over 65 percent of new high-tech companies are located in 10 states.** Yet compared to just 2 years ago, the distribution appears to be leveling off with the top three states—California, Massachusetts, and New York—all experiencing share declines. *See p. 157.*
- **Approximately 11 percent of small high-tech companies are foreign-owned—up from 9 percent 2 years ago.** The United Kingdom is the largest foreign holder of U.S. high-tech companies, followed by Japan and West Germany. *See p. 158.*

Emerging Technologies

- **A U.S. Government assessment of world leadership in 12 emerging technologies ranks the United States as the leader in 5:** artificial intelligence, biotechnology, high-performance computing, medical devices and diagnostics, and sensor technology; the United States trails Europe and Japan in just one area—digital imaging technology. By 2000, however, the United States is expected to have its leadership position challenged in all five technologies. *See p. 160.*

Introduction

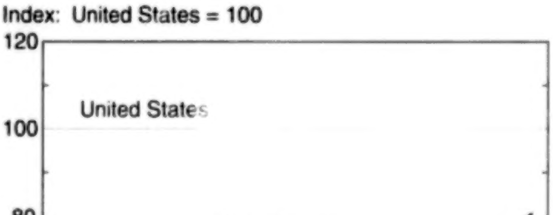
Chapter Focus

The United States has long been considered a leader in research and development (R&D), technology, and innovation. Standing at the forefront of technology and swiftly incorporating that technology into the country's industrial base contributed to a robust economy that provided Americans an enviable standard of living. (See figure 6-1.)

In the 1980s, however, U.S. leadership of the global economy was challenged as Japan, West Germany, and—more recently—certain newly industrialized countries grew to be equal and increasingly superior competitors in several U.S.-dominated markets. Contributing to the economic success of these nations have been large investments in R&D coupled with the development of an infrastructure that facilitates the incorporation and use of new technologies within their industrial sectors. Competition from the newly industrialized countries is expected to intensify during the 1990s as they increasingly undertake new product development (see Porter and Roessner 1991 and Balk 1991).

The recent U.S. technology policy articulated by the President's Office of Science and Technology Policy emphasizes the connection between a strong science and technology (S&T) base and future economic growth (see OSTP 1990). The development and deployment of new technology within the U.S. industrial sector is seen as "critical" for the United States to prosper in the global competition of the nineties and beyond (see National Critical Technologies Panel 1991). Although there are many other factors that determine a nation's ability to compete in the global marketplace, this chapter focuses on trends in industrial R&D and technology and the market competitiveness of U.S. high-technology products.[1]

Figure 6-1.
Real gross domestic product per capita



See appendix table 6-1.

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[1] As competition in the global marketplace intensifies, the factors influencing a nation's economic competitiveness multiply. Several of these factors include the differing national standards addressing the environment, worker safety, product integrity, and worker compensation. Another such factor of growing concern is the quality of a nation's education system and its ability to train a workforce that can operate the new manufacturing technologies.

Chapter Organization

The chapter opens with a discussion of the global competitiveness, in both foreign and domestic markets, of manufactured products that incorporate high levels of R&D. New data on royalties, fees, and technology agreements are used to gauge U.S. competitiveness in terms of intangible (intellectual) property and technological know-how.

The second section describes trends in industrial funding and performance of R&D, focusing particularly on the high-tech manufacturing sector as it compares with other sectors of the U.S. economy. A discussion of patent activity follows which describes trends in U.S. and foreign activity in the United States, technology field and industry, citation rates, and trends in foreign countries. Next, information gained from a new Census Bureau survey is presented on the industrial sector's use of advanced technologies in manufacturing operations.

The role of small business in high-technology industries is explored next, primarily through new information on the technology areas that seem to attract new business formations, generate employment and export activity, and attract foreign capital. Sources of startup funding for small business are also discussed.

The final section looks at the future in light of recent U.S. policy statements that tacitly acknowledge the connections between technology, industry, and U.S. competitiveness. A discussion of the U.S. position in several important technology areas vis-à-vis Japan and Europe is included.

The Global Markets for U.S. Technology

The market competitiveness of a nation's technological advances, as embodied in new products and processes, can serve as an indicator of the effectiveness of that country's S&T system. The marketplace thereby provides a commercial-based evaluation of a country's science and technology.

In the United States, two parallel developments—the growing import penetration of the U.S. domestic market and the large U.S. trade deficits of recent years—have drawn attention to the country's ability to compete in an increasingly international economy. In particular, the recent erosion of U.S. competitiveness in high-technology product markets has led policymakers to examine the role of the Nation's S&T in supporting and restoring U.S. leadership in the global marketplace.

The fastest growing industries in the United States are predominantly high-tech ones (see ITA 1991, p. 16, tables 4 and 5). High-tech industries generally

- Invest more heavily in manufacturing technology than do other manufacturing industries, and
- Support higher compensation to the production workers employed.[2] (See text table 6-1.)

Consequently, high-tech manufactures have become an important component of the U.S. gross economic output and thereby of the U.S. standard of living.

This section discusses U.S. "competitiveness," broadly defined as the ability of U.S. firms to sell products in the marketplace. The concept of a nation's global competitiveness incorporates both its ability to export and compete against imports in the home market. The analysis in this section relies heavily on data compiled by the Organisation for Economic Cooperation and Development (OECD) and the U.S. Department of Commerce (DOC).[3]

Throughout this section, industry-level data are presented for manufactured goods disaggregated by (1) those industries producing products that embody above average levels of R&D in their development (hereafter referred to as the ***high-technology industries***) and (2) all other manufacturing industries.[4]

The Global Market

The global market for high-tech manufactured goods is growing at a faster rate than that for other manufactured goods. In constant dollar terms (1980), global production by high-tech industries nearly doubled from 1980 to 1988, while production in other manufacturing industries grew by just 16 percent.[5] (See appendix table 6-2.) Output by high-tech industries represented 25 percent of global production of all manufactured goods in 1988, up from 17 percent in 1980.

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[2] For more extensive data on average earnings, see BLS (1991) and Hadlock, Hecker, and Gannon (1991).

[3] The OECD member countries account for over 75 percent of global exports of manufactured goods and account for an even higher percentage of overall exports of high-technology goods (ITA 1985, p. 43). The 25 countries reporting to OECD are Australia, Austria, Belgium/Luxembourg, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States, West Germany, and Yugoslavia (Yugoslavia participates in OECD with a special status).

Although the OECD data set does not include several nations of increasing importance in technology markets—most notably, the East Asian newly industrialized countries—it does provide a reasonable approximation of global commercial activity.

[4] For purposes of this analysis, the following industries make up the high-tech category (International Standard Industrial Classification—ISIC—codes are in parentheses):

- Industrial chemicals (ISIC 351),
- Drugs and medicines (ISIC 3522),
- Engines and turbines (ISIC 3821),
- Office and computing machinery (ISIC 3825),
- Communication equipment (ISIC 3832),
- Aerospace (ISIC 3845), and
- Scientific instruments (ISIC 385).

The categorization used here is more restrictive than the Department of Commerce's DOC-3 high-technology category which includes "space technologies" and ordnance. See ITA (1983). The other manufacturing category does not include agriculture or services.

[5] The conversion into constant 1980 dollars is done in two steps:

1. Product-specific price changes are removed by deflating the current dollar series for each product category (for all countries) using the price index (1980 = 1.0) for the corresponding industry in Data Resources, Inc./McGraw-Hill's 430-sector inter-industry model of the U.S. economy.
2. All production series for a given country are multiplied by the ratio of the U.S. gross national product deflator to the gross domestic product deflator of that country to adjust for differences in the general rate of inflation.

During the 1980s, the United States reigned as the leading producer of high-tech products, although its lead was—and continues to be—challenged, primarily by Japanese industry. (See appendix table 6-3.) While the U.S. share of global shipments of high-tech manufactures declined from 40 percent in 1980 to 37 percent in 1988, Japan's market share increased from 18 to 27 percent. Estimates for 1989 and 1990 indicate a continued decline in U.S. market share.[6] European producers (those in the 12 countries of the European Community—EC) also experienced a decline in high-tech global market share during the 1980s. A notable exception among the EC countries was the United Kingdom, which increased its market share slightly during this period. (See figure 6-2.)

In the increasingly competitive environment of the 1980s, the United States, Japan, and Europe moved resources toward the manufacture of higher value, technology-intensive goods and away from more labor-intensive manufactures. In 1988, U.S. high-tech manufactures represented 29 percent of total U.S. production of manufactured output, up from 20 percent in 1980. High-tech manufactures accounted for 21 percent of Europe's total production in 1988, compared with 16 percent in 1980. (See appendix table 6-4.) But the Japanese economy made the greatest leap forward in this respect, virtually pulling even with the United States in 1984 and surpassing it by 1987.

The market competitiveness of individual U.S. high-tech industries varies. (See figure 6-3.) Of the seven

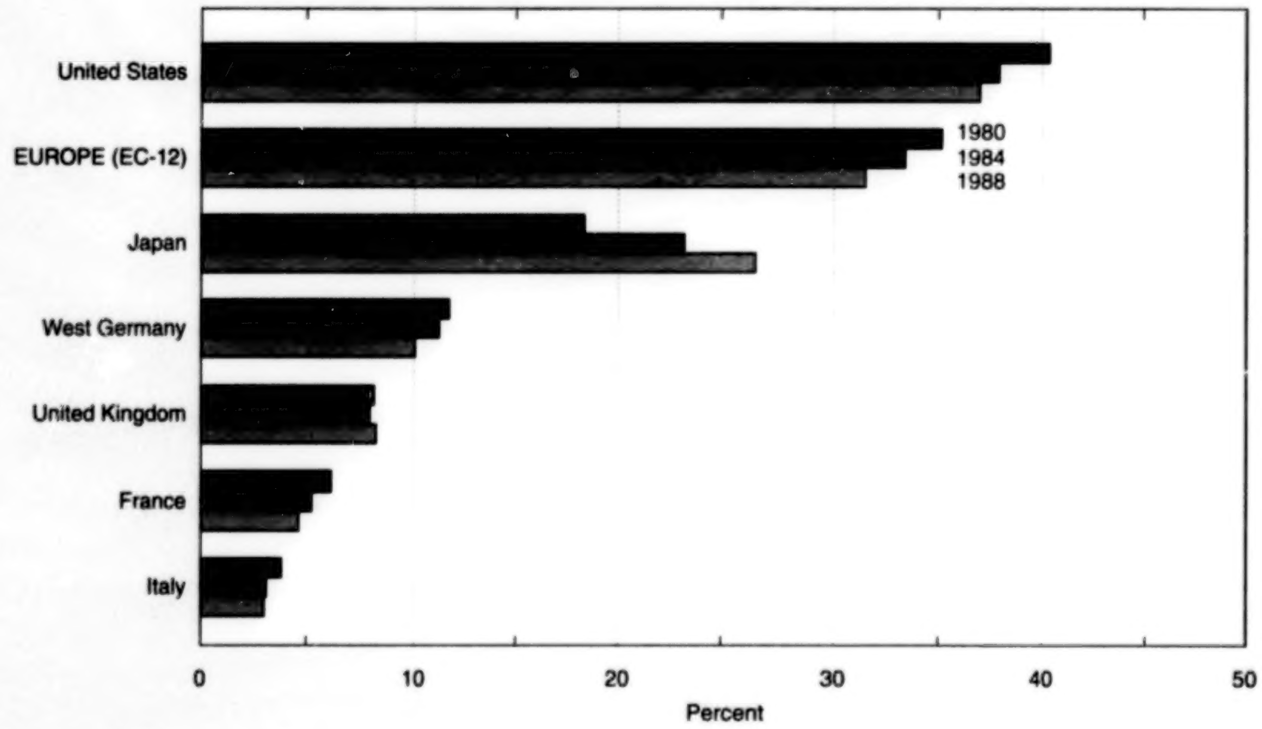
Text table 6-1.
Capital expenditures and wages, by industry: 1988

Industry and SIC code	Capital expenditures per production worker	Average hourly wage
High-tech manufacturing		
Space propulsion, 3764	$16,642	$17.25
Aircraft, 3721	7,296	16.01
Chemicals, 28	22,650	13.20
Computers, 3571	20,581	10.75
Other manufacturing		
Furniture, 251	1,318	7.33
Footwear, 314	642	6.11
Apparel, 23	720	6.35

SOURCE: International Trade Administration, Department of Commerce, *1991 U.S. Industrial Outlook*, (Washington, DC: DOC, 1991).

Science & Engineering Indicators – 1991

Figure 6-2.
Country share of global high-tech markets



See appendix table 6-3.

Science & Engineering Indicators – 1991

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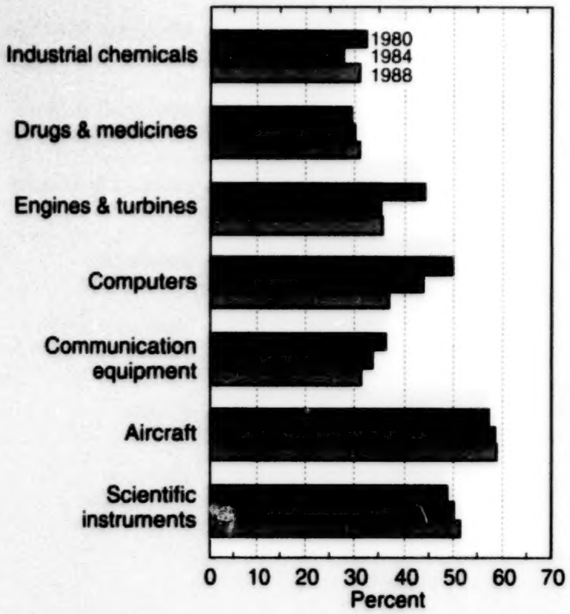
[6] Estimates for 1989 and 1990 were provided by Data Resources, Inc./McGraw-Hill.

Figure 6-3.
U.S. global market share, by high-tech industry



See appendix table 6-3. *Science & Engineering Indicators – 1991*

industries that form the high-tech grouping, three U.S. industries—those producing scientific instruments, drugs and medicines, and aircraft—gained global market share during the 1980s. Estimates for these same industries for 1989-90 show only one, scientific instruments, continuing to gain global market share. Estimates for the U.S. aircraft industry are far less optimistic; they suggest a loss of market share, primarily to European aircraft producers.

The Home Market

A country's home market is often thought of as the natural destination for its manufactured output. For obvious reasons—including proximity to the customer and common language, customs, and currency—marketing at home is easier than marketing abroad.

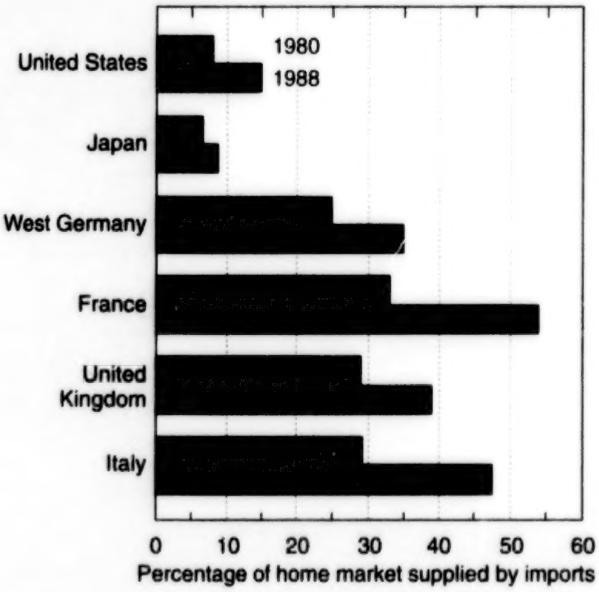
But in today's global marketplace, the most competitive product in terms of price, quality, and ability to satisfy the customer's needs wins the sale—regardless of its origin. Thus, in the absence of prohibitive trade barriers, the intensity of competition faced by domestic producers in their home market can approach and even exceed the level of competition faced in foreign markets. Given the large size and appetite of the U.S. market, examination of U.S. competitiveness at home is critical to an understanding of the country's global competitiveness.

Import Penetration: High-Tech Markets. During the 1980s, demand for high-tech products in the home markets of the major OECD industrialized countries was increasingly met by foreign suppliers. (See figure 6-4.) Imports supplied about 8 percent of U.S. purchases of high-tech products in 1980; by 1988, this percentage had risen to 15 percent. European economies are more heavily dependent on foreign technologies than is the United States. For example, in 1980, imports supplied 29 percent of the United Kingdom's domestic consumption of high-tech manufactures; by 1988, the import share rose to 39 percent. West Germany imported 25 percent of its high-tech product needs in 1980 and 35 percent in 1988.[7]

The Japanese home market, historically the most self-reliant, also increased its purchases of foreign technologies during the 1980s—but only during the latter half of the decade. From 1980 to 1985, imports of high-tech manufactures fluctuated around 6.5 percent of Japanese domestic consumption. By 1986, these imports rose to 8.4 percent and to 8.8 percent by 1988. Estimates for 1989 and 1990 suggest a continuation of this upward trend.

Import Penetration: Japanese and U.S. Home Markets, by Industry. Both the U.S. and Japanese domestic markets are becoming increasingly internationalized in all high-tech industries. (See figure 6-5.) For example, during the 1980s, the U.S. computer industry experienced the greatest rate of increase in import competition from other industrialized countries, especially Japan.[8] Foreign suppliers made significant gains in several high-tech industries in Japan; however, these industries tended

Figure 6-4.
Import penetration of high-tech markets



See appendix table 6-5. *Science & Engineering Indicators – 1991*

to be product areas in which Japanese industry has yet to assert itself. In fact, the Japanese increase in imports of U.S.-made aircraft and engines may very well be linked to recent Japanese efforts to develop its own aerospace industry (see ITA 1991, p. 22-9).

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[7] Throughout this chapter, data for Germany are for West Germany alone and do not include the former East Germany.

[8] Information on the source of imports is derived from product-level trade data.

Overseas Markets for High-Tech Products

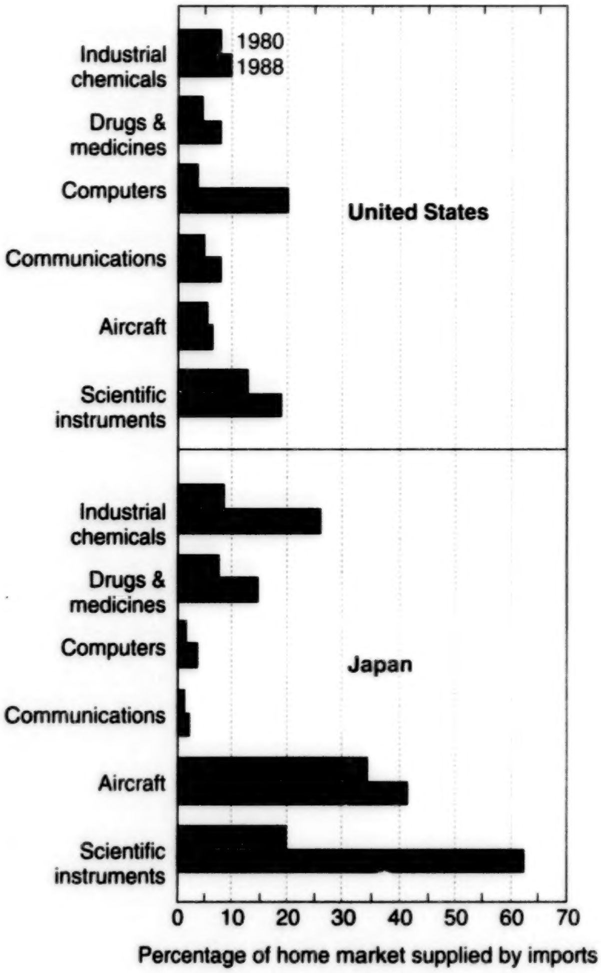
Historically, the United States has not been an economy oriented toward serving foreign markets. The sheer size of the U.S. economy provided the U.S. business community with large markets that supported its operations and typically accommodated most of its growth. In fact, exports account for a smaller proportion of manufacturers' shipments in the United States than in any other industrialized economy. Consequently, in the past U.S. commerce generally had relatively little need or incentive to investigate overseas markets (see Council of Economic Advisers 1989, pp. 234-38). The mounting trade deficits of the 1980s changed this situation, inciting concern about the need to expand U.S. exports.

The following discussion examines trends in sales of U.S. high-tech manufactures outside the United States. These trends in U.S. competitiveness are analyzed in two ways. The broader view of U.S. competitiveness outside the United States is given by the U.S. *share of foreign markets*. The discussion of this topic examines U.S. producers' experience in competing against both foreign producers and other countries' domestic producers overseas.[9] The U.S. *share of export markets* is examined next; this measures U.S. producers' experience in competing against foreign producers in foreign markets.

Foreign Markets. Despite their domestic focus, U.S. producers are important suppliers of high-tech products in overseas markets. Still, the 1980s proved to be a challenging time for them, as their share of foreign markets dropped from 10 percent in 1980 to 7.6 percent in 1985. The strength of the U.S. dollar during the early eighties hampered U.S. competitiveness globally. As a consequence, U.S. producers were challenged to be more innovative in improving both product performance and manufacturing efficiency. Better products coupled with a weakening dollar led to a steady rise in foreign market share after 1985 and through at least 1988. (See figure 6-6.)

During the early eighties, other (non-high-tech) U.S. industries experienced a similar loss of foreign market share. Unlike the high-tech industries, they were slower to regain market position. Throughout the 1980-88 period, high-tech industries held twice the foreign market share of other U.S. manufacturing industries.

Figure 6-5.
Import penetration of high-tech markets: United States and Japan



See appendix table 6-5. *Science & Engineering Indicators – 1991*

Export Markets. U.S. industries are still the world's leading exporters of high-tech products.[10] U.S. industry accounted for 23 percent of global high-tech exports in 1988, compared with 15 percent for Japan and 14 percent for West Germany. Both the U.S. and West German shares declined during the eighties, while Japan's share of high-tech exports grew significantly. Of the high-tech industries examined, the U.S. 1988 export share was highest in the aircraft and computers industries. (See figure 6-7.) Japan's communication industry led all nations

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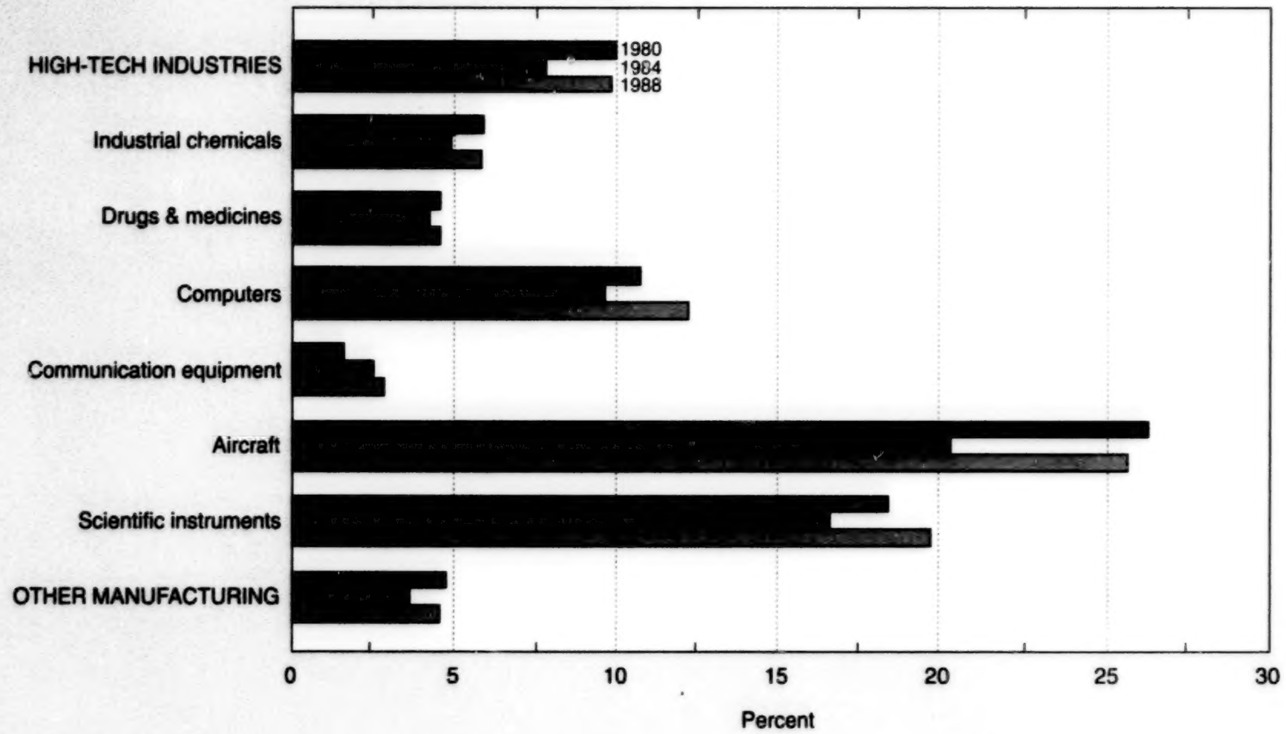
[9] Foreign market size is calculated by subtracting U.S. apparent consumption of high-tech products from total OECD shipments of same. Foreign market share is differentiated from export market share by adding the ***home market shipments*** of non-U.S. producers to the denominator.

[10] Trade data (exports and imports) are available on a product-level basis; production data are not. To conform with the production and trade data used elsewhere in this chapter, the discussions of export activity and trade balances are classified by industry. The industry-level definition of high-technology trade used here shows more midterm fluctuations in the U.S. trade than the trend portrayed using product-level data. Yet, using term endpoints, 1980 and 1988, reveals consistent trends regardless of the definition employed. See DOC (1983) and Abbott (1991) for technical discussions of alternative high-tech definitions.

Figure 6-6.
U.S. share of foreign markets, by industry



See appendix table 6-6.

Science & Engineering Indicators – 1991

in exports in 1988 as did West Germany's industrial chemicals and drug industries.

U.S. Trade Balance

During the 1980s, the United States maintained a consistent trade surplus for the identified high-tech manufactures, but ran consistent deficits in other manufactures: Trade balances for both categories declined over the period. (See figure 6-8.) In several European countries, high-tech trade surpluses rose through the mid-eighties, then fell sharply through 1988. Among the industrialized countries, only Japan experienced steady growth of its high-tech manufactures trade surplus during the decade. (See figure O-23 in Overview.)

The U.S. trade surplus in high-tech manufactures in 1988 was half the size of its 1980 trade surplus. Again, the U.S. dollar's rollercoaster ride during the eighties affected U.S. competitiveness in the home market as well as in foreign markets. Six of seven U.S. high-tech industries showed deteriorating trade balances during the 1980s—three (communications equipment, engines and turbines, and scientific instruments) experienced trade deficits. The U.S. aircraft industry had a sharp decline in its trade surplus through the mid-eighties before recovering and exceeding the 1980 surplus in 1988.

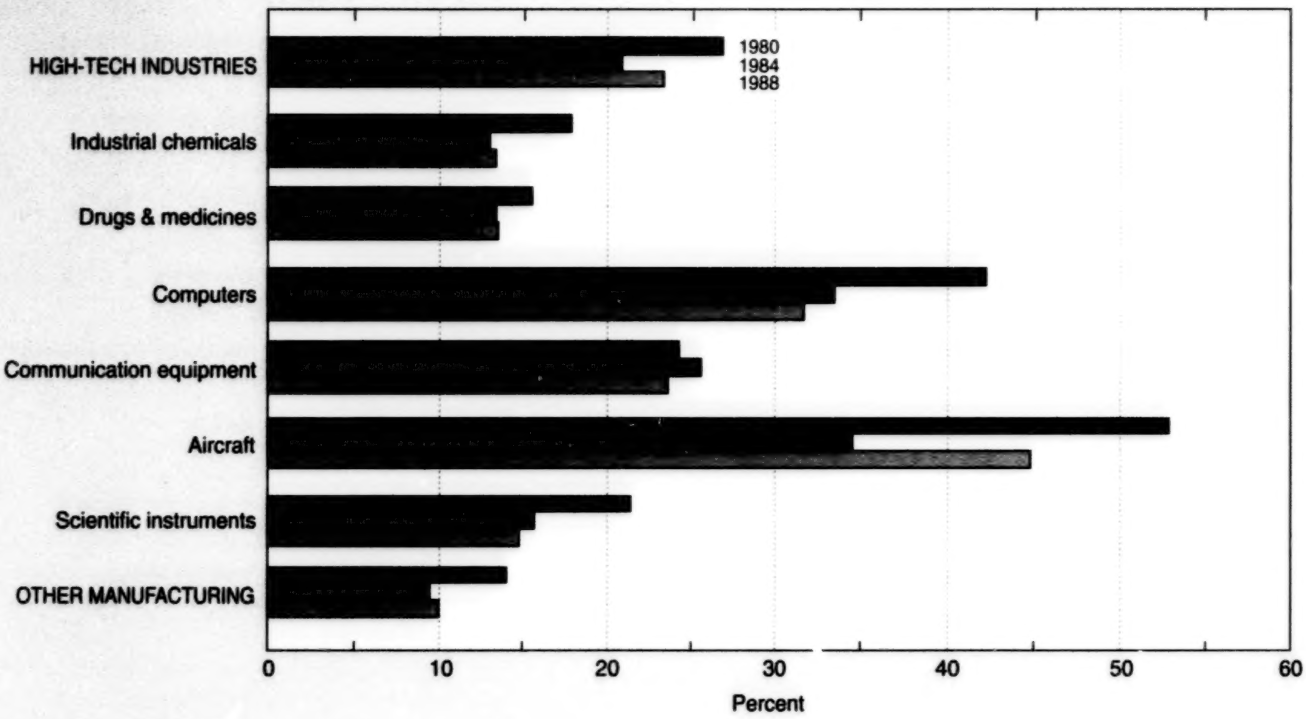
Royalties and Fees From Technology Agreements

Receipts and payments for patents and technical knowledge are another indicator of firms' technological prowess. Transactions among unaffiliated firms—in which prices are set through a market-related bargaining process—tend to reflect the exchange of technology and its market value at a given point in time. The record of the resulting receipts and payments also provides an indicator of the production and diffusion of technical knowledge.

All Agreements. The United States is a net exporter of technology sold as intellectual property. Royalties and fees received from foreigners have been, on average, almost four times that paid out to foreigners by U.S. firms for access to their technology. U.S. receipts from such technology sales totaled $1.9 billion in 1989, up from $1.6 billion in 1987. (See appendix table 6-9.)

Japan is the largest consumer of U.S. technology sold in this manner. In 1989, Japan accounted for 47 percent of all such U.S. receipts, while the Western European countries together represented 27 percent. South Korea increased its purchases of U.S. technological know-how sharply during the 3 years for which

Figure 6-7.
U.S. share of global exports, by industry



See appendix table 6-7.

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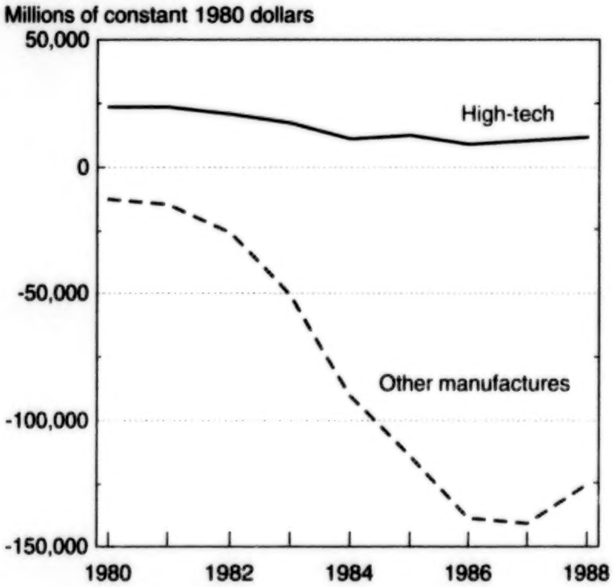
data are available, becoming the second largest consumer of U.S. industrial processes with a 9-percent share in 1989, up from just a 2-percent share in 1987. (See figure 6-9.)

To a large extent, the U.S. surplus in the exchange of intellectual property is driven by trade with Japan and the newly industrialized Asian countries. In 1989, U.S. receipts were nearly eight times its payments in licensing transactions entered into with Japan. On the other hand, the U.S. trade surplus with Europe in sales of technological know-how declined over the past 3 years (1987 to 1989). West Germany represented the largest European trading partner in these transactions; it was also the only country in the world with which the United States had a persistent technical knowledge trade deficit.

New Agreements. The total flows of receipts and payments of royalties and license fees are generated both from new agreements and those made in previous periods that are still in force. The data discussed above thus do not reflect current U.S. technology flows resulting from new agreements. Although data on receipts and payments from new technology agreements are not available from U.S. sources, the Government of Japan has developed data that disaggregate receipts and payments by new and existing agreements. (See appendix tables 6-11 and 6-12.) Since Japan is the dominant customer for U.S. technology sold through this channel and is a major force in high-tech fields, these data provide useful insight about the relatively high level of U.S. technology sold via new technology agreements.

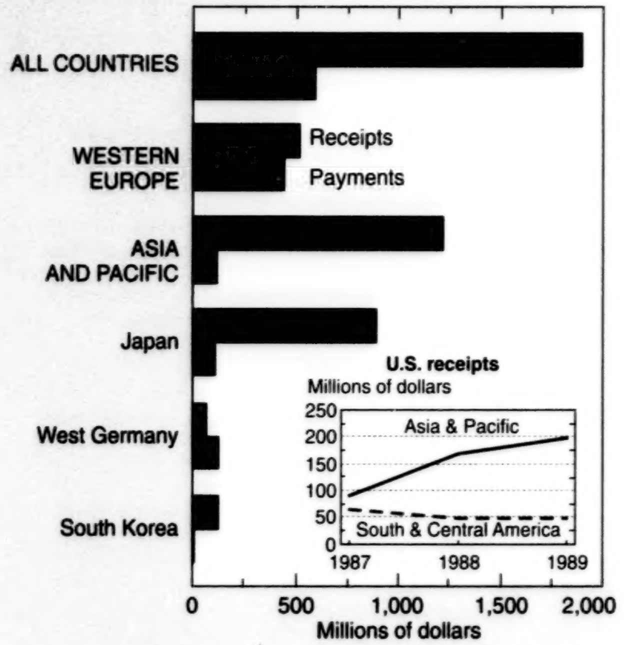
Figure 6-8.
U.S. trade balance in manufactures



See appendix table 6-8.

Science & Engineering Indicators – 1991

Figure 6-9.
U.S. royalties and license fees generated by exchange of industrial processes: 1989



See appendix table 6-9. *Science & Engineering Indicators – 1991*

From 1984 to 1988, the United States entered into, on average, over 900 new agreements per year with Japan involving the exchange (both purchase and sale) of technological know-how. There were close to three new agreements calling for U.S. exports to Japan of technological know-how for every one that represented a U.S import of Japanese technology. The average value of these agreements was fairly equitable—about 37 million yen ($285,000) per agreement for Japanese purchases and 34.7 million yen ($267,000) for those agreements involving Japanese sales of technological know-how to the United States.[11] The U.S. trade surplus in these high-tech sales with Japan nearly tripled in size during this 5-year period. In 1988, Japan entered into 11 times as many agreements for the purchase of technological know-how with the United States as with its next largest trading partner, West Germany.

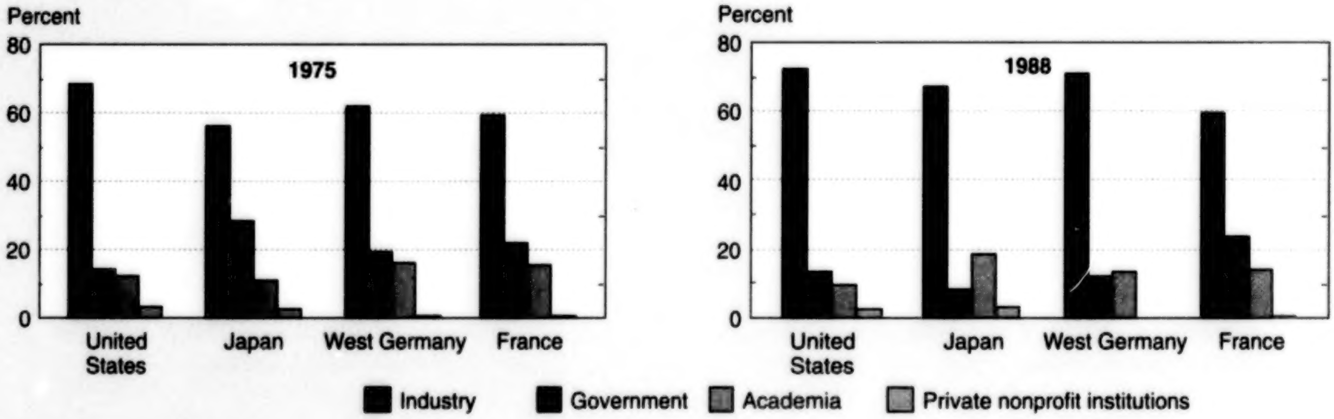
Japan apparently continues to consider the United States a fertile field from which to harvest new advances in technology. The surplus the United States enjoys in its technological know-how trade with Japan does not rely solely on technological advances developed in the past but is supported by current inventive activity as well. Although sales of technological know-how contribute positively to the balance sheets of U.S. firms and the U.S. economy in the short term, there has been ongoing controversy regarding the long-term consequences.[12]

Industrial R&D

International Comparisons

In all industrialized countries, the industrial sector is the leading performer of R&D. In the United States, more than 73 percent of all R&D expenditures are for R&D performed in industry (1988). (See appendix table 6-13.) Among other large industrialized market economy countries, West Germany has a similar share of R&D performed by industry. Japan, the United Kingdom, and—especially—France have somewhat lower shares, although even in France about 60 percent of national R&D expenditures are in industry. (See figure 6-10.) Except for France,

Figure 6-10.
National R&D expenditures, by sector of performance



See appendix table 6-13. *Science & Engineering Indicators – 1991*

these percentages represent increases in the share of R&D performed in industry over the 1975-88 period. Japan and West Germany showed the largest shifts to the industrial sector.

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[11] Converted at an exchange rate of 130 yen per U.S. dollar.

[12] In 1988, the United States had a surplus of approximately $200 million generated from new technology agreements with Japan, but suffered a deficit in high-tech *merchandise* trade with Japan of $5 to $22 billion (depending upon the definition used). Recent developments in the aerospace industry typify the controversy. In this industry, as international joint production ventures grow (e.g., FSX codevelopment with Japan, General Dynamic's F-16 coproduction program with Turkey, and the F-18 coproduction program with South Korea), exports of complete U.S.-built aircraft could decline in the future.

Private industry was the source of 50 percent of all funds spent for R&D in the United States; the Federal Government funded most of the remainder. Nearly all of industry's funding was directed toward R&D that would be performed within industry. About 1 percent was spent on university research and almost 1 percent on research in nonprofit institutions. Compared to the United States, Japan and West Germany received considerably larger shares of their national R&D funds from private sources. France and, until recently, the United Kingdom had less of their R&D funded by industrial sources.[13]

Since the early 1970s, the trend in all five countries has been for an increasing percentage of national R&D to be financed by industry. (See figure 6-11 and appendix table 4-2.) In the United States, however, the trend rose until 1982 and remained more or less stable through 1991. This leveling off was primarily due to the buildup of federally supported R&D for defense during the 1980s.

Industrial R&D Expenditures

Funds for industrial R&D come almost exclusively from two sources: private industry itself and the Federal Government.[14] Total estimated current dollar expenditures in the United States for industrial R&D increased markedly between 1979 and 1989, rising from $38.2 billion to $101.6 billion—an average annual increase of close to 10.3 percent. Current dollar estimates for 1990 and 1991 show continued growth. (See appendix table 6-15.) After adjusting for inflation, however, the growth rate of industrial R&D is reduced to 5.2 percent per year during 1979-89, with a significant slowdown occurring during the last 5 years. From 1979 to 1984, industrial R&D expenditures grew at an annual rate of 7.4 percent

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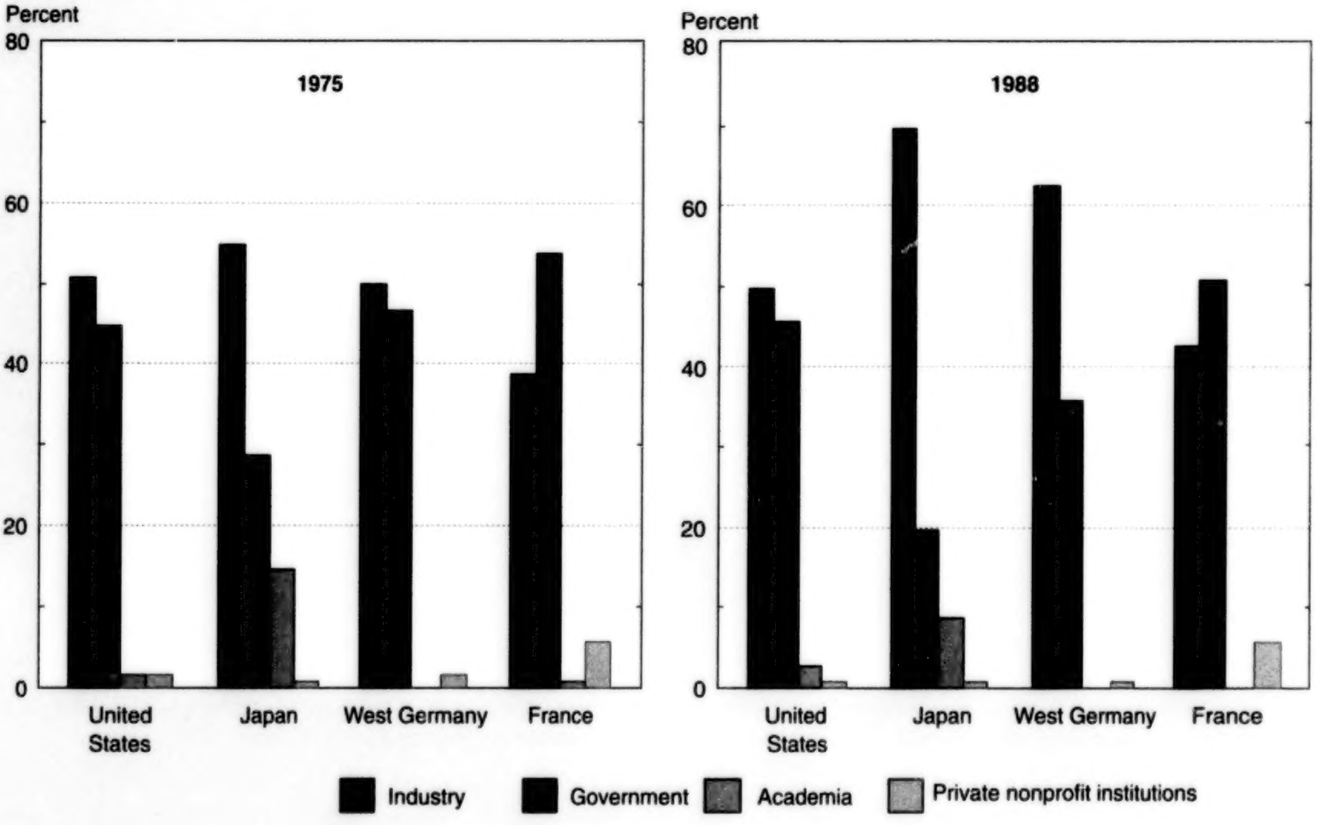
[13] The data for France and the United Kingdom include R&D funding provided by public, as well as private, corporations. The level of private funding for their industrial R&D was therefore lower than is shown on figure 6-10.

[14] Some companies perform "independent research and development." IR&D is in-house R&D intended to better prepare the companies to bid on National Aeronautics and Space Administration or Department of Defense projects. Some of these expenditures are later reimbursed by the agency as overhead charges allocated to contracts. IR&D expenditures represent less than 5 percent of total R&D expenditures by industry. See chapter 4, "Independent Research and Development," p. 98.

Figure 6-11.
National R&D expenditures, by source of funds



See appendix table 6-13.

Science & Engineering Indicators – 1991

in constant dollars compared with 3.0 percent during 1984-89. And by 1989, constant dollar expenditures actually declined—the first time this had occurred since 1975. Estimates for 1990 and 1991 indicate that industrial R&D expenditures continued to decline in inflation-adjusted dollars. (See figure 6-12.)

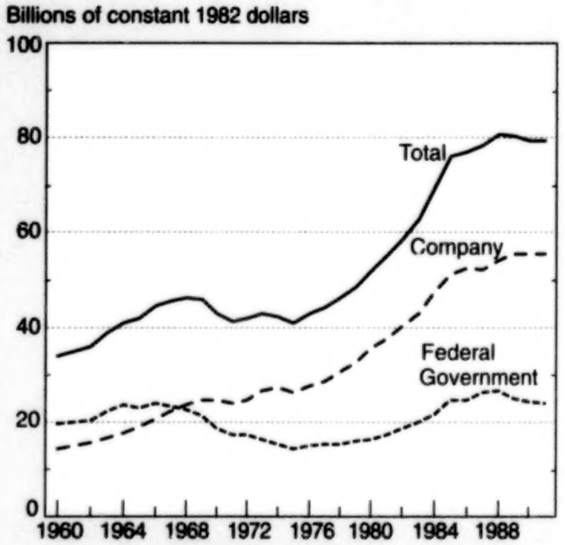
Trends in Company and Federal Funding

From the early sixties through the early eighties, the share of industrial R&D funding provided by companies themselves increased steadily. By 1984, private financing supported close to 69 percent of industrial R&D performance; in the early sixties, only about 42 percent was self-financed. (See figure 6-12.) This trend was reversed as the military buildup that began in the early eighties led the Federal contribution to first keep pace with—and to later increase more rapidly than—the private contribution. Since 1987, however, private financing has again outpaced Federal support.

During the 1960s, private funding for industrial R&D increased at an average rate of 6.6 percent per year, in constant dollars, while Federal support increased by 1.4 percent per year. Both private and Federal support for industrial R&D were cut back in the seventies: Private funding growth slowed to 2.8 percent annually, and Federal funding actually declined in inflation-adjusted dollars.

In the 1980s, U.S. policy refocused Federal funding toward development and upgrading of military technologies. U.S. industry was driven to escalate new product development in the face of growing foreign competition. Consequently, both private and Federal funding of industrial R&D increased significantly when compared with the previous decade—private funding doubled its growth rate to 5.4 percent a year, while Federal funding actually grew almost as fast at 4.5 percent per year. Most of this growth took place in the first half of the decade. The average annual growth rate during the early eighties was twice that of the latter half.

Figure 6-12.
U.S. industrial R&D expenditures, by source of funds



See appendix table 6-15. *Science & Engineering Indicators – 1991*

Estimates for 1990 and 1991 indicate that both Federal and company funding of industrial R&D declined when inflation is taken into account. The decline in Federal support stems from concern over the Federal budget deficit. The decline in company R&D funding can be attributed to several factors, including the following:

- Profit margins have been squeezed for some time because of the rise in competition that accompanies the increasing globalization of markets.
- The above factor, combined with the general softness in demand for industrial outputs evident in the past few years, has caused industry to look for ways to reduce its costs.
- In some firms, R&D labs have been decentralized, bringing them closer to company manufacturing operations as the result of restructuring and/or corporate mergers (SRS 1989 and SRS 1988).

Expenditures for Individual Industries

Individual industries show very different trends in their R&D expenditures and in the shares of those expenditures supported by private and Federal sources. For purposes of this analysis, industries are divided into three general groups: high-tech manufacturing, other manufacturing, and nonmanufacturing (including services).[15]

During the 1979-89 period, the high-technology manufacturing group's share of industrial R&D expenditures fluctuated narrowly around a 59-percent share of the total; concurrently, the share for all other manufacturing industries declined from 37 to 33 percent. Although nonmanufacturing industries accounted for the smallest share of the three groups, this was the only group whose share grew, doubling the 4-percent share it held in 1979 to an 8-percent share in 1989.

From 1979 to 1989—a rollercoaster period of economic slowdown followed by prolonged growth and a subsequent leveling off—total industrial R&D rose by an average of 5.2 percent per year in constant dollars. During this time, R&D within the three industry groups increased as follows:

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[15] The nonmanufacturing category includes all service-related and mining Standard Industrial Classification (SIC) codes; it does not include agriculture SICs. Appendix table 6-16 lists the SIC codes included, along with trends in R&D expenditures.

The high-tech manufacturing industries selected are those generally identified as having comparatively higher levels of R&D as a proportion of sales. Due to Census Bureau requirements to protect the confidentiality of firm data, industrial R&D data are not available for all industries normally included in the high-tech category.

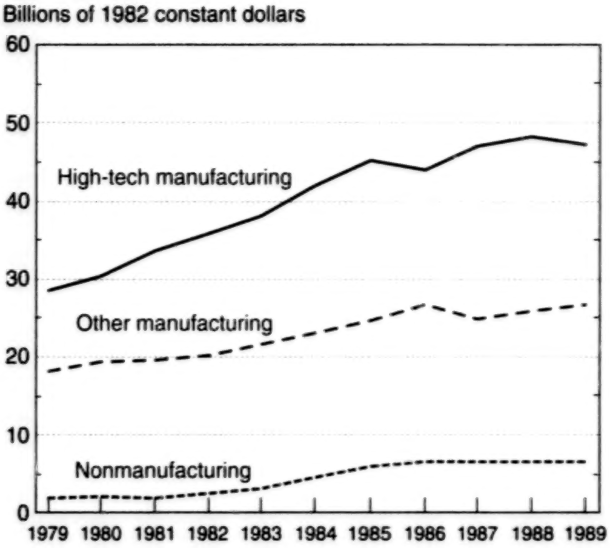
- High-tech manufacturing—5.2 percent per year,
- Other manufacturing—3.9 percent per year, and
- Nonmanufacturing—12.8 percent per year.[16]

Within the high-tech manufacturing group, several industries experienced above average R&D growth—chemical and allied products (including pharmaceuticals), electronic components, communication equipment, and aerospace. (See figure 6-13.) Firms whose primary activity involves providing computer-related and engineering services accounted for nearly half of the nonmanufacturing group's R&D expenditures and were responsible for most of the increases exhibited during 1987-89.

Trends in Funding for Individual Industries

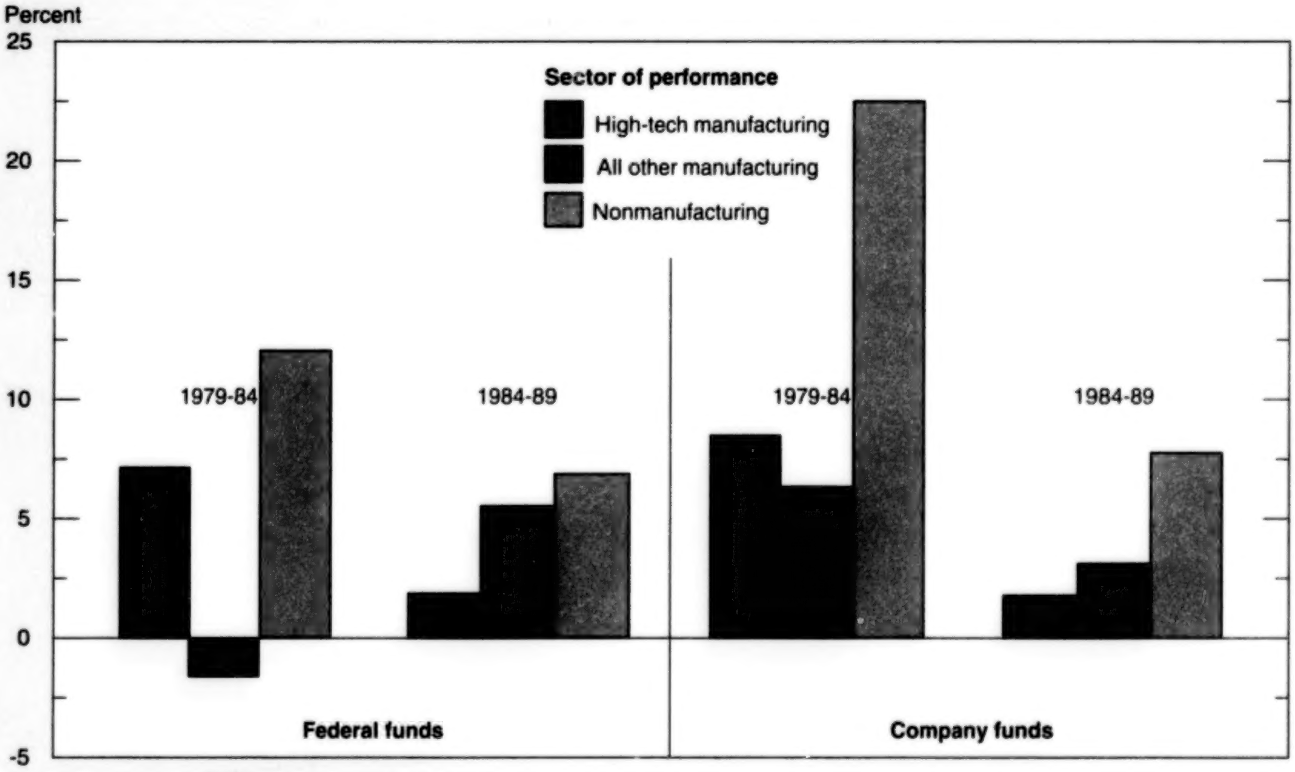
Company funding in high-tech manufacturing industries went up 5.2 percent per year during the 1980s after adjusting for inflation; it went up 4.8 percent per year in other manufacturing. (See appendix table 6-18.) Private funding of industrial R&D performed by nonmanufacturing industries grew at an average annual rate approaching 15 percent during this period, exceeding the 9.5-percent rate of growth in Federal support to this group. But in all three industry groups, funding of R&D slowed during the latter part of the decade. (See figure 6-14.) Two

Figure 6-13.
R&D expenditures, by industry group



See appendix table 6-16. *Science & Engineering Indicators – 1991*

Figure 6-14.
Real growth rates in funding of industrial R&D, by source and sector of performance



See appendix tables 6-17 and 6-18. *Science & Engineering Indicators – 1991* of the industries in which company-financed R&D grew fastest, the chemicals and computer manufacturing industries, were also faced with declining Federal support during this time.

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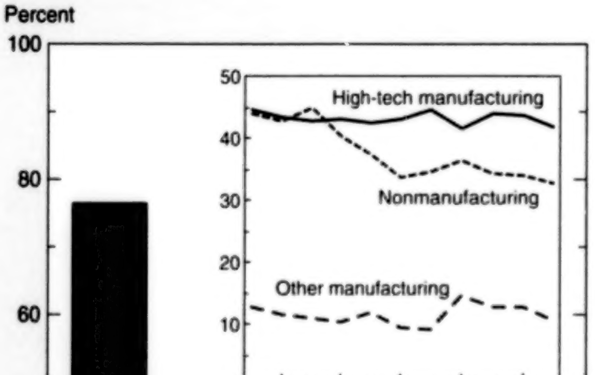
[16] The rapid rate of growth in R&D expenditures reported for the nonmanufacturing sector during the 1980s may be distorted by efforts to improve coverage of the service sector in the National Science Foundation's annual Survey of Industrial Research and Development starting with the 1987 survey. Although adjustments have been made to link data from previous samples, it remains uncertain whether the effects of the resampling have been completely removed.

Certain manufacturing industries—particularly aircraft and missiles and communication equipment, all of which have special military importance—received especially large portions of their R&D support from Federal sources. (See figure 6-15.) The Federal Government also provided a large share of R&D funding to certain nonmanufacturing industries. In 1989, it supplied nearly half of the R&D funds used by firms whose primary activity involves R&D and testing services and one-third of the R&D funds used by computer-related and engineering services firms.

In constant dollars, Federal support increased at an average rate of 4.5 percent per year from 1979 to 1989; this increase was directed to certain industries. In particular, Federal funding increased by an annual average of 7.7 percent per year in aerospace, 7.4 percent per year in fabricated metal products, and 7.7 percent per year in all nonmanufacturing. (See appendix table 6-17.) Federal support for R&D in the nonmanufacturing industries group more than doubled in constant dollars during this time, registering an annual increase of 9.5 percent. As noted earlier, Federal support to this group is substantially less in absolute dollars than that allocated to the manufacturing groups.

Figure 6-15.
Share of industrial R&D funding provided by Federal Government: 1988



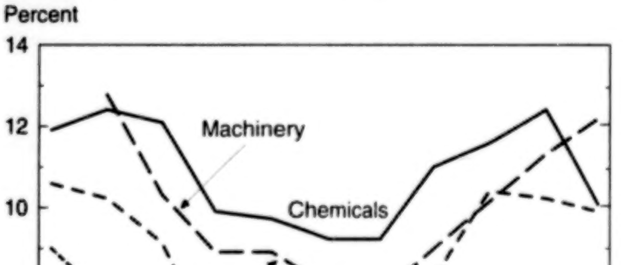
See appendix table 6-19. *Science & Engineering Indicators – 1991*

Company-Financed R&D Performed Outside the United States

From 1979 to 1989, U.S. firms generally increased their funding of R&D performed outside the country.(See appendix table 6-20.) This funding growth did *not* keep pace with the rise in company-financed R&D performed within the United States, however. The share of total company-financed R&D performed outside the United States declined steadily from the period high of 9.7 percent in 1979 to a low of 6.0 percent by 1985. From 1985 to 1989, U.S. firms' overseas R&D increased faster than that performed domestically, with its share rising to 8.5 percent by 1989. Nonetheless, this share was still below the 1979 level.

The industries with the highest levels of company-financed R&D performed overseas in 1989 were chemicals and allied products—10.1 percent—and transportation equipment (especially motor vehicles and aircraft)—12.2 percent. (See figure 6-16.) Nonmanufacturing industries had the lowest share of privately financed R&D being conducted overseas, despite an almost threefold increase in this share during the eighties, from 0.6 percent in 1979 to 1.6 percent by 1989.

Figure 6-16.
Share of company-financed R&D performed outside the United States, by industry



See appendix table 6-20. *Science & Engineering Indicators – 1991*

Patented Inventions[17]

One of the important benefits of R&D is the stream of new technical inventions that may in turn be embodied in innovations—i.e., in new or improved products, processes, and services. *Patenting trends* can serve as an indicator—albeit one with certain limitations—of the success of U.S. industry in producing such innovations.[18] Specifically, Griliches (1990) and others suggest that patent data provide good indicators for measuring technical change and inventive input and output over time. Further, U.S. patenting by foreign inventors enables measurement of the levels of invention in those foreign countries (see Pavitt 1985). Foreign patenting can also serve as a leading indicator of new competition in a country's home market. This section describes broad trends in patenting over time, by field, and by industry by both U.S. and foreign inventors. It briefly discusses patenting trends in foreign countries and describes an indicator that attempts to identify technically important patented inventions. In addition, information on patenting activity in other countries is presented. (See "Patenting Activity in Foreign Countries," p. 150.)

Granted Patents by Owner

Patents Granted to Americans.[19] From 1977 through 1983, the number of patents granted to Americans declined irregularly.[20] This trend was reversed at about the time the United States came out of the recession of the early eighties; patent grants to Americans have been increasing fairly rapidly since then. By 1989, U.S.-origin patenting registered a new high when about 50,000 patents were granted to U.S. resident inventors. However, foreign patenting in the United States rose at a quicker rate in the post-recession period (1983-90) than did U.S. domestic patenting—8.6 versus 5.3 percent per year.[21] (See figure 6-17 and figure O-21 in Overview.)

Patents granted to American inventors can be further analyzed by patent ownership at the time of grant. Inventors who work for private companies or for the Federal Government commonly assign ownership of their patents to their employer; self-employed inventors usually retain ownership of their patents. The owner's sector of employment is thus a good indication of the sector in which the inventive work was done. In 1990, 71 percent of granted patents were owned by corporations.[22] This percentage has varied within a narrow range (between 70 and 74 percent) since 1970. Consequently, trends in U.S. patenting are by and large trends in patenting by corporations. (See figure 6-18.)

Individuals are the next largest group of patent owners. In 1970 individuals owned 21 percent of patents granted. Their share rose to 27 percent in 1980 and was 26 percent in 1990. The Federal share of patents has varied from a high of 4.1 percent in 1976 to a low of 1.8 percent in 1988 and 1989.[23] Finally, about 1 percent of patents granted to American inventors are owned by foreign corporations or governments.

In 1989 the number of patents granted in the United States jumped 22 percent.[24] U.S. inventors received 53 percent of the U.S. patents granted that year, representing the first upturn in their share of granted patents since 1977. The increase in U.S. share is a reflection of the successes of individual inventors. The patenting share for U.S. corporations actually declined in 1989, and U.S. Government-owned patents accounted for about the same share of total as in 1988.

Patents Granted to Foreign Inventors. The number of U.S. patents granted with foreign origin also increased sharply in 1989, although not as dramatically as did those with U.S. origin. Thus, the share of total patents granted to foreign inventors in 1989 fell from 48.1 percent in 1988 to 47.5 percent. Of new U.S. patents

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[17] Although the U.S. Patent and Trademark Office grants several types of patents (e.g., design patents), this discussion is limited to utility patents, which are commonly known as "patents for inventions."

[18] Patenting indicators, while instructive and convenient, have some well-known drawbacks, including the following:

- *Incompleteness*—many inventions are not patented at all, in part because laws in some States already provide for the protection of industrial trade secrets.
- *Inconsistency across industries*—industries vary considerably in their propensity to patent inventions; consequently, it is not advisable to compare patenting rates between different technologies or industries.
- *Inconsistency in quality*—the inventions patented can vary considerably in quality. (Patent citation rates, discussed on pp. 152-53, are one method for dealing with this question of varying quality.)

Despite these and other limitations, patents provide a unique and convenient source of information on innovation.

[19] The U.S. Patent and Trademark Office grants patents to both U.S. and foreign inventors. Patent origin is determined by the residence at the time of grant of the first-named inventor as specified on the face of the patent. Patents "granted to Americans" are actually U.S.-origin patents.

[20] The number of patents granted to all countries dipped in 1979 because the Patent Office could not afford to print all the patents approved that year.

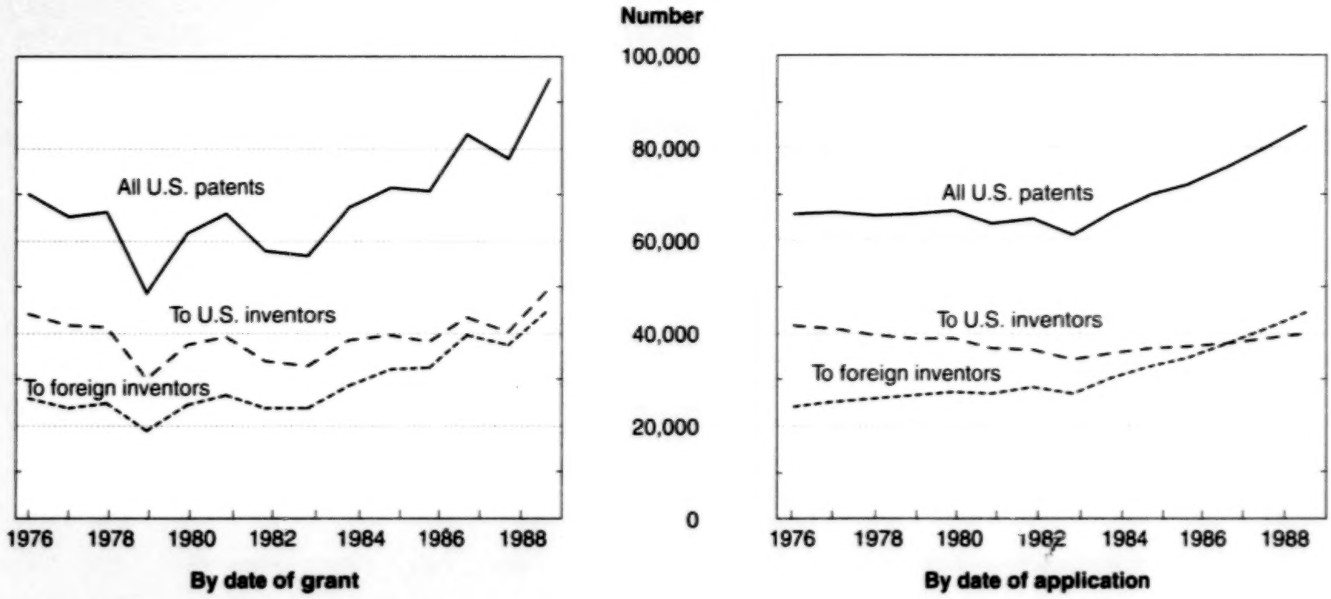
[21] Both U.S. and foreign patenting declined from 1987 to 1988. This decline, one of many oscillations that appear in patenting data by year of patent grant, may be due to the especially low number of patents awarded in 1986 because of budget restrictions at the Patent Office. This development, in turn, led to an unusually high number of patent grants in 1987 as patents were carried over into that year. Also, utility patent applications dropped in 1983. Since it can take 2 to 3 years before a successful application matures into a patent, this drop may also have contributed to the low number of patent grants in 1986. See "Granted Patents by Date of Application," p. 149.

[22] About 2 percent of patents granted to Americans in 1989 were owned by U.S. universities and colleges. The Patent Office counts these as being owned by corporations. For further discussion of academic patenting, see chapter 5, "Patents Awarded to U.S. Universities," pp. 130-31.

[23] Federal inventors frequently obtain a statutory invention registration (SIR) rather than a patent. An SIR is not ordinarily subject to examination and costs less to obtain than a patent. Also, an SIR gives the holder the right to use the invention but does not prevent others from selling or using the invention as well.

[24] Part of this increase may be attributed to Patent Office efforts to reduce "pendency," the time between receipt of a patent application and completion of its processing.

Figure 6-17.
U.S. patents granted, by nationality of inventor



NOTE: Estimates are shown for 1987-89 for patents by date of application. See appendix tables 6-21 and 6-22.

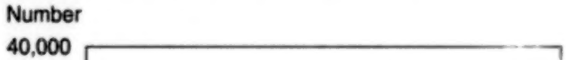
Science & Engineering Indicators – 1991

with foreign origin, those owned by individuals increased in number but declined as a share of the 1989 total, as did those owned by foreign governments. Foreign corporation-owned patents increased in sufficient numbers in 1989 to maintain their share of total from 1988. Among 1989 patents with foreign origin, only those granted to U.S. entities increased both absolutely and relatively.

Foreign patenting is highly concentrated by country of origin. (See figure 6-19.) Since 1975, Japan has received more U.S. patents than any other foreign country. Japanese inventors have steadily increased their share, receiving 22 percent of all U.S. patents in 1990, compared with under 10 percent in 1977. West German inventors received around 9 percent of U.S. patents from 1977 to 1990—generally rising slightly through 1986 and declining slightly thereafter. The share of U.S. patents owned by United Kingdom inventors followed an irregular but declining trend during 1977-90, dropping from a high of 4.1 percent in 1977 to a low of 3.1 percent in 1990. Over this same period, the French share fluctuated narrowly around 3.3 percent. (See figure O-21 in Overview.)

Comparing foreign patenting growth rates in the United States in the wake of the 1980s recession reveals the expanding roles of Japan and Europe as technology competitors as well as identifies several other countries with a demonstrated capacity to generate new technologies. During the 1983-90 period, the

Figure 6-18.
U.S. patents granted, by class of owner



See appendix table 6-21. *Science & Engineering Indicators – 1991*

average U.S. patenting growth rate was 8.6 percent per year among foreign countries. Countries with above average growth rates were

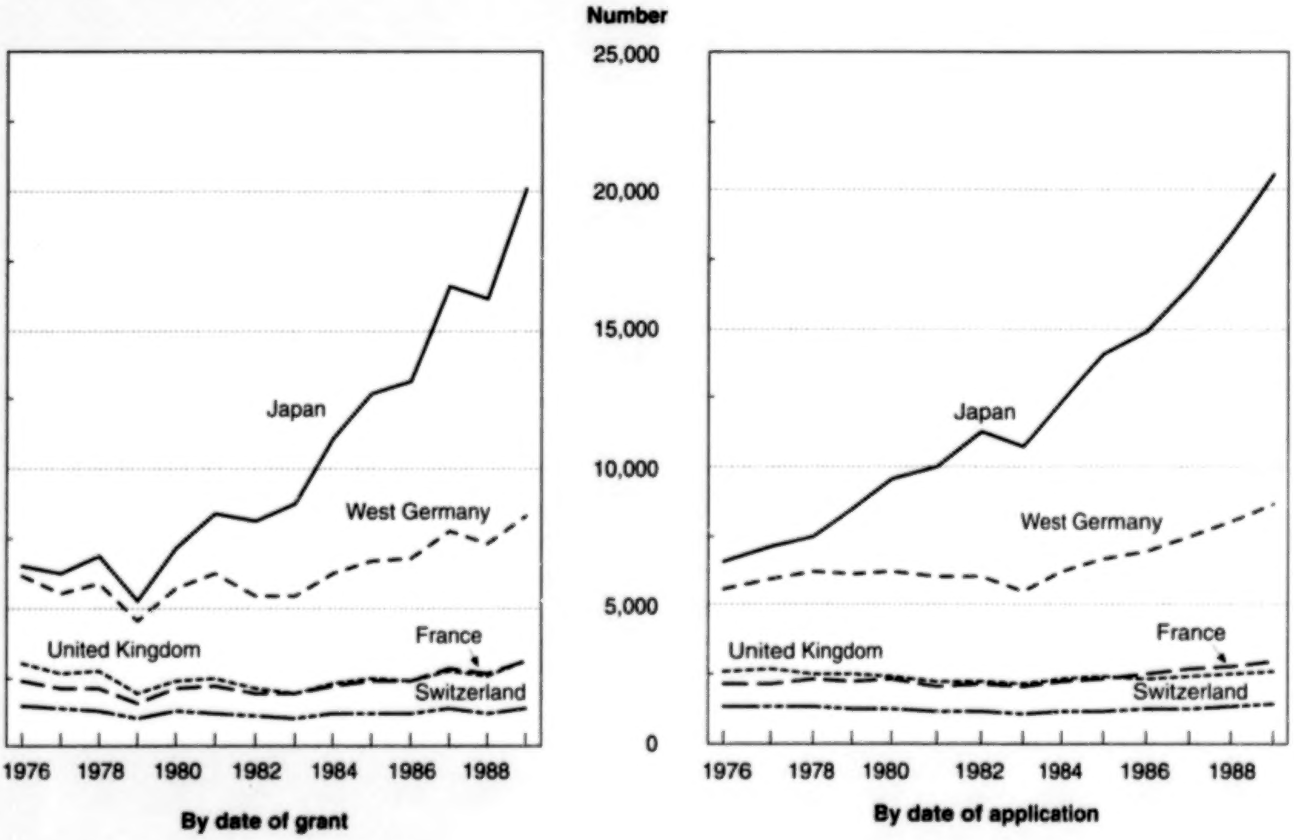
- Taiwan, 41.3 percent per year (731 patents granted in 1990);
- South Korea, 36.0 percent per year (224 patents);
- Hong Kong, 20.6 percent per year (52 patents);
- Japan, 12.0 percent per year (19,444 patents);
- Sweden, 10.5 percent per year (1,257 patents); and
- Switzerland, 9.2 percent per year (1,848 patents).

The patenting growth rate for the United States during this time was 5.3 percent per year (47,195 patents). Despite the dramatic recent increase in patent activity by the newly industrialized countries of East Asia—particularly Taiwan and South Korea—these countries, as a group, accounted for just over 1 percent of the U.S. patents granted in 1990.

Granted Patents by Date of Application[25]

Patent data by year of grant show considerable oscillation from year to year, primarily because of fluctuations in the rate at which the Patent Office processes applications. To remove the effect of these fluctuations, granted patents can be allocated to the years in which they were applied for. The application date is roughly 2 or 3 years before the year of grant and is thus closer to the time at which the invention actually took place. When displayed by year of application, patenting data show much smoother trends.

Figure 6-19.
U.S. patents granted to foreign inventors, by nationality of inventor



NOTE: Estimates are shown for 1987-89 for patents by date of application. See appendix tables 6-21 and 6-22.

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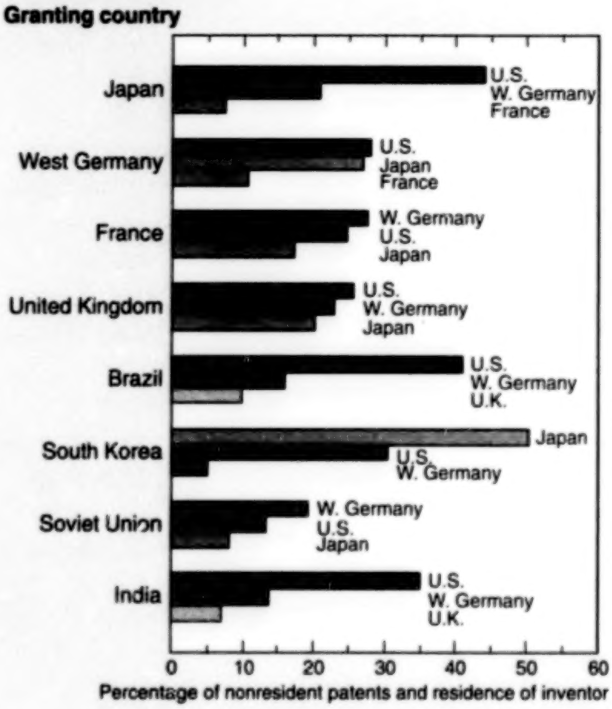
[25] Because the Patent Office has not yet completed the examination process for numerous applications filed during 1987-89, it is not known how many of these applications will ultimately be granted. Consequently, this analysis of patenting trends by year of application is confined to the 1963-86 period.

Note, however, that the data series for patenting by date of application shows a dip in 1983 for several countries. In fact, the number of applications from many countries was especially high in 1982 and correspondingly low in 1983. A new schedule of higher fees was introduced in late 1982, contributing to an acceleration of filings in 1982 and fewer in 1983.

Patent Activity in Foreign Countries

Nonresident inventors account for varying shares of total patent activity around the world. Countries that patent extensively in the United States—for example, Japan and West Germany—are active in other countries as well. Similarly, U.S. inventors are themselves active and successful in patenting inventions around the world. Contrary to the recent declining trend for U.S. inventors at home, recent foreign patent activity suggests that U.S. inventors are not only successful at obtaining patents in neighboring countries, but garner a large and increasing share of nonresident patents in Europe, Japan, South Korea, Brazil, and India. (See figure 6-20.)

Figure 6-20.
Patents granted to foreigners in 1989, by granting country



See appendix table 6-31. *Science & Engineering Indicators – 1991*

From 1976 to 1983, patented *applications* in the United States decreased at an average rate of slightly over 1 percent—primarily because the success rate of patent applications from U.S. inventors declined. In contrast, foreign-origin patenting grew at 1.6 percent a year. (See figures 6-17, 6-18, and 6-19.)

From 1984 to 1986, U.S. patenting by year of application exhibited a positive growth rate, bolstered by both U.S. and foreign inventors. Patenting by foreign inventors grew at an average annual rate three times that of U.S. inventors. (See appendix table 6-22.)

During the post-recession period for which data are available (1983-86), several countries demonstrated above average growth in patented applications, as follows:

- Italy, 14.0 percent per year;
- Belgium, 11.7 percent;
- Japan, 11.4 percent;[26] and
- West Germany, 8.0 percent.

But as with patent grant data, it was the East Asian newly industrialized countries that exhibited the highest growth rates during 1983-86, as follows:

- Taiwan, 44.4 percent a year;
- South Korea, 29.3 percent; and
- Hong Kong, 20.0 percent.

Although these growth rates are building on a far lower base of patent applications than the major industrialized countries, they suggest that these countries have begun to reap benefits from their R&D and technology-producing investments.

Patents by Patent Office Classes[27]

A country's distribution of patents by technical area provides a key to understanding that country's contribution to important fields of technology. This section compares and discusses the various key technical fields favored by inventors from various countries in their U.S. patenting.

Fields Favored by U.S. and Japanese Inventors.[28] To some extent, there is an inverse relationship between U.S. and Japanese patenting. (See appendix tables 6-23 and 6-24.) For example, Japanese patenting in the United States emphasizes such technically and commercially important technologies as photocopying, photography, dynamic information storage and retrieval, television, motor vehicles, and internal combustion engines. All of these are technologies in which U.S. corporate inventors are least active. It is probably no coincidence that

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[26] Japanese applications lead to grants more often than do applications from any of the other countries discussed here. For example, an estimated 68.3 percent of the patent applications filed by Japanese inventors in 1985 will lead to patent grants, compared to 65.9 percent for West Germany and 59.5 percent for the United States.

[27] Information in this section is based on the Patent Office's classification system which divides patents into approximately 370 active classes. Using this system, patent activity for U.S. and foreign inventors in recent years can be compared by developing an *activity index*. This index measures a country's patenting activity within a given class. For any given year, the activity index is the proportion of patents in *a particular class* granted to inventors in a specific country divided by the proportion of *all* patents granted to inventors in that country.

Because U.S. patenting data reflect a much larger share of patenting by individuals without corporate or government affiliation than do data on foreign patenting, only patents granted to *corporations* are used to construct the U.S. patenting activity indexes.

[28] Narin and Olivastro (1986) compare the fields emphasized by U.S. and Japanese inventors in their U.S. patenting; also see Narin and Frame (1989).

Japanese penetration of U.S. markets in many of these areas has followed.

U.S. patent activity is especially high in the wells and mineral oils classes, areas that are among those in which the Japanese patent the least. This inversion no doubt stems from the difference in natural resource availability between the two countries. U.S. corporations also emphasize patenting in chemical areas (including biochemistry); analytical and immunological chemical testing is a least emphasized class for Japan. Compared with Japanese patenting activity, Americans are also much more active in various biotechnology, pharmaceutical, and communication classes.

Fields Favored by Other Major Industrialized Countries. As with Japan and the United States, patent data for West Germany, France, and the United Kingdom show each country's emphases among important technological areas. West German patent activity emphasizes printing, ammunition and explosives, and chemicals including fertilizers and plastics. West Germany has increased its activity in these areas substantially during the 1980-89 period. (See appendix table 6-25.)

French patent activity emphasizes, and has grown in, nuclear technology and communications. (See appendix table 6-26.) The French also show high activity in biotechnology; this may signal continued competition for U.S. biotech firms.

Like the French, the British are quite active in the biotech patent classes and communication technologies. (See appendix table 6-27.) They share the U.S. emphasis on aeronautics. Like the Germans, the British do not patent much in the United States in semiconductor manufacturing, nor do they particularly patent in areas of Japanese emphasis, such as dynamic information storage and retrieval and photography.

Fields Favored by Newly Industrialized Countries. For the first time in the Science & Engineering Indicators series, patent activity data are presented for two of the more successful newly industrialized countries, Taiwan and South Korea. (See appendix tables 6-28 and 6-29.) Their recent patent activity in the United States can be seen as an indicator of areas of technological development as well as a leading indicator of U.S. product markets likely to see increased competition.

Taiwan illustrates the movement of the newly industrialized countries to new technology development and improvement of previously established technologies. As recently as 1980, patent activity by inventors from Taiwan in the United States was predominantly in the area of toys and other amusement devices. By 1989, however, Taiwan was emphasizing more highly technical classes, receiving patents in such areas as communications technology, semiconductor manufacturing processes, and internal combustion engines.

U.S. patenting by South Korean inventors is heavily concentrated in the patent classes that include electrical products and electronic component technologies. In fact, patents in these areas account for about half of the top 30 patent classes in which South Korean inventors are most active. Although Korea has high activity in less technologically significant areas such as chairs and seats and amusement devices, it is also very active in such commercially important technologies as semiconductor devices and computer peripheral equipment. South Korea is already a major supplier of computers and peripherals to the United States, and these patent activity data show that the country's inventors may be developing the improvements that will support Korea's future competitiveness in this technology.[29] South Korea also patents heavily in the United States in television technology, and has made dramatic gains in penetrating this U.S. market (ITA 1991, p. 31-3). (See "Television Technologies," p. 152.)

Patents by Standard Industrial Classifications

As an alternative to the U.S. Patent Office's system for classifying inventions, patents can also be classified by Standard Industrial Classification (SIC) industries.[30] Except for a moderate increase in the drugs and medicines industry, the U.S. share of patents dropped in the remaining nine industries shown on appendix table 6-30. The drop was especially great in

- Office, computing, and accounting machines—from 61 percent to 44 percent,
- Motor vehicles and other transportation equipment—from 53 to 41 percent,
- Communication equipment and electronic components—from 64 to 49 percent, and
- Aircraft and parts—from 51 to 44 percent.

The falloff in these industries was not due to a decline in U.S. patenting—which increased significantly from 1980 to 1989 in these and other important technology classes—but rather to a more rapid rate of increase by inventors from Japan, Canada, Taiwan, and South Korea. Overall, the share of U.S. patents held by inventors from West Germany, France, and—in particular—the United Kingdom declined.

Japan's share of U.S. patents approximately doubled from 1980 to 1989, going from 12 to 21 percent of the total. The Japanese share increased in each of the 10 industries shown, with an especially large increase in

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[29] South Korea was the fifth largest foreign supplier of computers and peripherals to the United States in 1989. See ITA (1991), p. 28-2, and ITA (1990).

[30] In this classification system, each patent class is associated with the SIC industry that would produce the class's product or apparatus or carry out its process steps. See OTAF (1985), p. 26. The Concordance computer program maintained by the Patent Office converts patent counts from the Patent Office classification system into counts in terms of the 1972 SIC system. This section focuses on international comparisons of 10 commercially significant SIC industries; these are listed in appendix table 6-30.

Television Technologies

In 1923, U.S. inventors revolutionized information transmission with the television receiver. Thirty-one years later, U.S. inventors ushered in a new era of television technology with color TV. U.S. manufacturers went on to dominate the consumer markets for television-related products, supplying 90 percent of the American market in 1970 (see Council on Competitiveness 1988). Since then, U.S. leadership as an innovator in television technologies declined: subsequently, so did its share of the consumer products market for television products. Japan then became the locus of television-related innovation; it soon became the recognized supplier of high-quality products in television and many other electronics products.

Now South Korea is also emerging as an innovative force in this field. Between 1980 and 1989, South Korean inventors received a total of 22 patents for television-related technologies. All of these were granted during the last 4 years of the period: 1 in 1986, 5 in 1987, 6 in 1988, and 10 in 1989. The 10 patents awarded to South Korean inventors in 1989 tied them with Italy for a seventh-place rank in that commercially important technology field. Moreover, one of Korea's largest manufacturers of television sets recently purchased a 5-percent share of the Zenith Electronics Corporation, the only U.S.-owned maker of televisions. Zenith also concluded licensing agreements that provided the Korean firm with access to Zenith's picture quality enhancement technology (*New York Times* 1991).

The television technologies market seems on the verge of revolutionary change with the advent of high-definition TV (HDTV). HDTV has attracted much attention from U.S. policymakers and has been represented as a pivotal technology that could provide the vehicle for reestablishment of a U.S. industry foothold in the consumer electronics market (Senate Committee on Governmental Affairs 1989). As noted, the United States currently claims only one U.S.-owned manufacturer of consumer televisions. (There are, however, several foreign-owned television manufacturing plants in the United States.) But the potential commercial value of the HDTV market and from other product markets that will incorporate HDTV technology may entice further U.S. business activity in this field (see OTA 1990 and American Electronics Association 1988).

office, computing, and accounting machines (rising from 17 to 40 percent). Japanese patenting in this field nearly reached the level of U.S. domestic patenting. Large increases in Japanese patenting also occurred in communication equipment and electronic components (from 15 to 31 percent) and in motor vehicles and equipment (from 16 to 32 percent).

The Canadian share of U.S. patents increased slightly over the period (from 1.7 to 2.1 percent), with the greatest share increases in drugs and medicines, industrial inorganic chemicals, and plastics and synthetic resins.

Although the *numbers* of U.S. patents granted to inventors from West Germany, the United Kingdom, and France increased between 1980 and 1989, their *shares* of total patents granted declined. Of the 10 commercially important industries examined, the West German share fell in 6. The French, whose overall share dropped the least among these three countries, also lost shares in 6 of the 10 product fields, and dropped sharply in 2 of these, motor vehicles and aircraft and parts. The number of U.S. patents granted to British inventors increased the least of the three in this year-to-year comparison; consequently, the United Kingdom declined the most in terms of share of total patents. The British share fell in 8 of the 10 commercially important industries, and fell sharply in 4.

The newly industrialized countries—Taiwan and South Korea in particular—once again showed the most dramatic increase in U.S. patent activity in 1989. Although their shares of total patenting remain quite small, it is noteworthy that their growth appears to have taken place in the more commercially important technologies. For example, in 1989 inventors from Taiwan were granted seven patents in the aircraft and parts industry and six in the engines and turbines industry compared with one and two, respectively, in 1980. These are two industries in which the United States has historically been very strong both in inventive activity and in global market share. South Korea, as noted earlier, is very active in television-related technologies. (See "Television Technologies," above.)

Products from Taiwan and South Korea currently compete with U.S., Japanese, and European products in the marketplace. Their recent patent activity portends even greater competition in the marketplace in the not-too-distant future.

Citations From Patents to Previous Patents

Not all patents are equally significant. One method for gauging the relative values of different patents is analysis of interpatent citations. These citations, generally provided on the front page of a patent document, reference previous patents and are supplied by the patent examiner. These citations indicate the "prior art," i.e., they disclose technology in related fields of invention that should be taken into account in judging the novelty and "patentability" of the present invention. Therefore, the number of citations that a patent receives from the front pages of subsequent patents can serve as an indicator of the original patent's technical importance.[31]

Citation to Patents, by Country. Of the 10 countries that received the most patents from 1980 to 1987, Japanese patents were most often cited and were cited with increasing relative frequency. (See text table 6-2.) U.S. patents were cited second most frequently, with the United Kingdom, The Netherlands, Canada, and West Germany following behind.[32]

These data suggest an order of technical significance for the patents granted to these countries. However, the frequency with which a country's patents are cited is explained in part by the technical fields in which it receives patents. Interpatent citation is more frequent in some fields than in others, and some countries (e.g., Japan and The Netherlands) concentrate their patenting somewhat in fields where citation is more frequent, but not necessarily more technologically valuable.

To correct for this, the data on text table 6-2 can be adjusted by giving every country the same distribution of patents by SIC field, i.e., the distribution that applies to the United States. The resulting citation frequencies per patent for the 1980 data are as follows:

- Japan, 3.63;
- United States, 3.58;
- Canada, 2.97;
- United Kingdom, 2.94;
- The Netherlands, 2.86;
- Sweden, 2.81;
- France, 2.63.
- West Germany, 2.61;
- Switzerland, 2.50; and
- Italy, 2.34.

Thus, although there are some changes in the ranking of countries, Japan remains first and the United States second in interpatent citations.

Citation to Patents, by Country and Industry.[33] The macro approach just discussed can yield distortions when used in international comparisons. These distortions are caused by the different mix of industries in which a nation tends to patent and the differing propensities of those industries to patent. Industry-level comparisons of citation rates help to refine the examination of the value of a country's patents in the United States.[34]

Japanese patents were the most highly cited in patent fields associated with 6 of 16 industries; they were the most highly cited in 10 industries when only foreign-owned patents are considered. Industries in which Japanese patents were highly cited are largely similar to those industries in which Japanese products are highly competitive.[35] (See appendix table 6-32.) British-owned patents were the most highly cited in 3 of the 16 industries and in 4 when comparing just foreign-owned patents. French and West German patents were each the most highly cited in only one industry.

U.S. patents granted were most highly cited in 5 of the 16 industries. Patents for drugs and medicines were especially strong, but familiarity with the procedures and requirements surrounding the development of such products for U.S. consumption may contribute to U.S. superiority in this field.

Citations to U.S.-Owned Patents, by Sector of Owner. U.S. corporations own the patents that are most often cited, while patents owned by the U.S. Government and by U.S. individuals are cited least often. (See text table 6-2.) U.S. corporations, in 1975 and 1980, received patent citations as often as did Japanese holders of U.S. patents. Since almost all Japanese patents filed in the United States are owned by corporations,[36] it may be more appropriate to compare the citations received by Japanese (and other foreign) patents with those received by U.S. corporation-owned patents. By this measure, U.S. patents were cited a bit more often than Japanese patents in 1975 and 1980 but somewhat less often when considering the more recent and limited data of 1985 and 1987. Foreign-owned U.S. patents have citation rates slightly below that of U.S. corporate-owned patents but greater than all other owner sectors.

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[31] Carpenter, Narin, and Woolf (1981) show that technologically important patents on average receive twice as many of these examiners' citations as does the average patent, thus helping to confirm the validity of interpatent citation as an indicator of patent quality.

In addition to examiners' citations on the front of the patent document, there are also citations from within the document, provided by the applicant, to earlier patents. Patents receiving high numbers of examiner citations also tend to receive high numbers of applicant citations. See Carpenter and Narin (1983).

[32] Text table 6-2 shows successive sharp increases in the number of citations per patent as the patents grow older. These increases occur because newer patents have had fewer years in which to be cited, not because of any general decline in the quality of patents. Data on citations received per patent are recorded as of the end of 1989. Consequently, the data shown for 1987 are especially incomplete.

[33] This discussion is based on an examination of the citation rates of patents granted in 1980 in 16 different industries; these industries are listed in appendix table 6-32.

[34] Of course, even an industry-level analysis is distorted somewhat by the diversity of product patents and their citation propensities within that industry.

[35] Japanese patents related to the aircraft and parts industry were also highly cited, but data in this field are confounded by the difficulty of distinguishing aircraft inventions from those in more conventional transportation technologies, such as motor vehicles. See Patent and Trademark Office (1985).

[36] In 1987, 96 percent of the U.S. patents granted to Japanese inventors were owned by foreign corporations, virtually all of which would be Japanese. Another 3 percent were owned by foreign individuals, and 1 percent had American owners.

Text table 6-2.
Citations from U.S. patents to earlier U.S. patents, by country of inventor or sector of owner of cited patents

	Country of inventor										
Grant year of cited patents	United States	Japan	The Netherlands	United Kingdom	West Germany	Canada	France	Switzerland	Italy	Sweden	Average, all countries
	Citations per citable patent										
1975	4.25	4.30	3.87	3.93	3.55	3.65	3.35	3.19	3.21	3.54	4.05
1980	3.58	3.79	3.28	3.12	2.86	2.85	2.82	2.73	2.66	2.62	3.39
1985	2.07	2.66	1.70	1.79	1.69	1.65	1.61	1.62	1.57	1.52	2.06
1987	1.01	1.30	0.84	0.82	0.75	0.78	0.77	0.73	0.64	0.61	0.99

	Sector of owner, for U.S. inventors				
	All U.S. inventors	U.S. corporations	U.S. Government	U.S. individuals	Foreign owners
	Citations per citable patent				
1975	4.25	4.49	3.29	3.66	4.36
1980	3.58	3.88	2.81	2.90	3.87
1985	2.07	2.25	1.66	1.57	2.07
1987	1.01	1.10	0.74	0.77	1.01

NOTE: Numbers shown will increase, especially those for more recent years, as patents continue to receive more citations.

SOURCE: Computer Horizons, Inc., unpublished tabulations (1990).

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Diffusion of Technology in the Industrial Sector

Historically, the U.S. manufacturing base has operated in state-of-the-art factories using cutting edge technologies to produce manufactures more efficiently than its competitors. This advantage has been a key factor in the Nation's world economic success (see Council on Competitiveness 1991 and Wolf 1991). Moreover, U.S. industry's incorporation of the newest technologies in its manufacturing operations has given its workers a substantial edge in productivity. Recently, however, improvements in U.S. productivity growth have lagged behind those of several other industrialized countries (see BLS 1989). (See figure 6-21.) American industry's failure to reinvest adequately is often cited as a leading cause for this decline in productivity (see Wolf 1991). Since 1980 among the major industrialized countries, the largest increases in manufacturing productivity were registered in the United Kingdom (55.5 percent), Japan (54.4), and Italy (47.7). U.S. productivity increased 40.5 percent during the same period (1980-89). Although West Germany (15 percent) and Sweden (20.9) underperformed the United States, their success in the international marketplace lends evidence to the importance of other factors in building competitive economies.

Industrial Use of Technology

In 1985, a report by the President's Commission on Industrial Competitiveness stressed the importance for U.S. industry's investment in the latest technologies and their rapid incorporation into U.S. manufacturing operations (President's Commission 1985). Recently, the Department of Commerce surveyed 10,526 manufacturing establishments concerning their current and planned use of advanced technology. The establishments were in five major industrial groups—fabricated metal products (SIC 34), industrial machinery and equipment (SIC 35), electronic and other electric equipment (SIC 36), transportation equipment (SIC 37), and instruments and related products (SIC 38).[37] Manufacturing establishments within these five categories accounted for nearly half of all employees and value added in the United States.[38]

The surveyed companies were asked for information on their current or planned use of 17 technologies in the following areas:

- Design and engineering (3 technologies),
- Fabrication/machining and assembly (5),
- Automated material handling (2),
- Automated sensor-based inspection and/or testing (2), and
- Communication and control (5).

Appendix table 6-34 lists all 17 advanced technologies.

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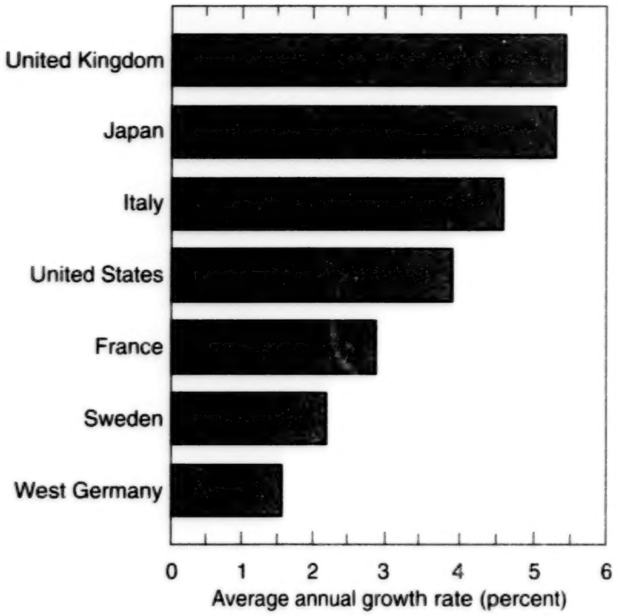
[37] The survey was performed by the Industry Division of the Bureau of the Census. (See Bureau of the Census 1989.) Surveyed establishments had 20 or more employees and were selected to represent the total universe of almost 40,000 manufacturing establishments classified in SICs 34 to 38.

[38] Coverage estimates were derived from the 1987 Census of Manufactures. See Bureau of the Census (1988).

Figure 6-21.
Manufacturing productivity growth rates: 1980-89



See appendix table 6-33. *Science & Engineering Indicators - 1991*

Nearly 70 percent of the establishments surveyed indicated that they currently use at least 1 of the 17 advanced technologies in their manufacturing operations; 23 percent reported use of 5 or more technologies.[39] Several characteristics seem to be associated with establishments' use of advanced technology. For instance, most *large plants* (79 percent) reported widespread use of advanced technologies—that is, use of five or more—compared with just 13 percent of the small establishments.[40]

Market value of the establishment's output also appeared to influence degree of technology use. Establishments producing goods with market unit prices of $10,000 or more had the highest probability of using advanced technologies (82 percent used at least one), and establishments whose output had a market unit price of under $5 had the lowest probability (68 percent). Of establishments with products between these two price extremes, about three-quarters reported use of at least one advanced technology.

International Comparisons of Technology Use

Surveys of technology use in manufacturing have been conducted in many other countries; two of these—those conducted in Canada and Australia—were modeled after the U.S. survey.[11] Despite their dissimilarities, the Canadian and Australian surveys provide an international context within which the U.S. survey data can be examined, albeit cautiously. For example, against the U.S. finding that technology use is positively influenced by plant size, the results from the Australian survey may be "artificially" low. The Canadian and Australian surveys also yielded certain qualitative information not developed in the U.S. survey that can contribute to an understanding of technology use by U.S. industry.

Compared with Canada and Australia, a significantly higher percentage of U.S. manufacturers use advanced technology in their operations.[12] (See appendix table 6-34.) In the U.S. survey of five major industries, 68 percent of the manufacturing establishments reported use of at least one advanced technology in their operations. Results from the Canadian and Australian surveys of all manufacturers show use of at least one advanced technology by 43 percent and 33 percent of respondents, respectively.

The most commonly used of the 17 advanced technologies in U.S. manufacturing is the numerically controlled machine, used by 41 percent of the surveyed establishments. Next most used was computer-aided design and engineering technology (CAD/CAE) which was reported in use by 39 percent of the establishments. (See figure 6-22.) Plants over 30 years of age were more likely to use numerically controlled machines than were plants under 5 years of age (50 percent versus 37 percent). When U.S. manufacturers were asked which of the specified advanced technologies they planned to use over the next 5 years, they selected those related to computerizing their production operations. Topping the list of such technologies were computers used for control on the factory floor. Coupled with present use of this technology, within 5 years 50 percent of the manufacturing plants will be using computers for controlling factory operations.

In the Canadian survey, programmable controller technology had the highest incidence of current use, followed by CAD/CAE technology. Like their U.S. counterparts, Canadian manufacturers planned to increase their use of CAD/CAE technology over the next 5 years, making it

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[39] Information on the extent of use was not gathered by the survey. Thus, establishments using 1 robot are not differentiated from those using 100.

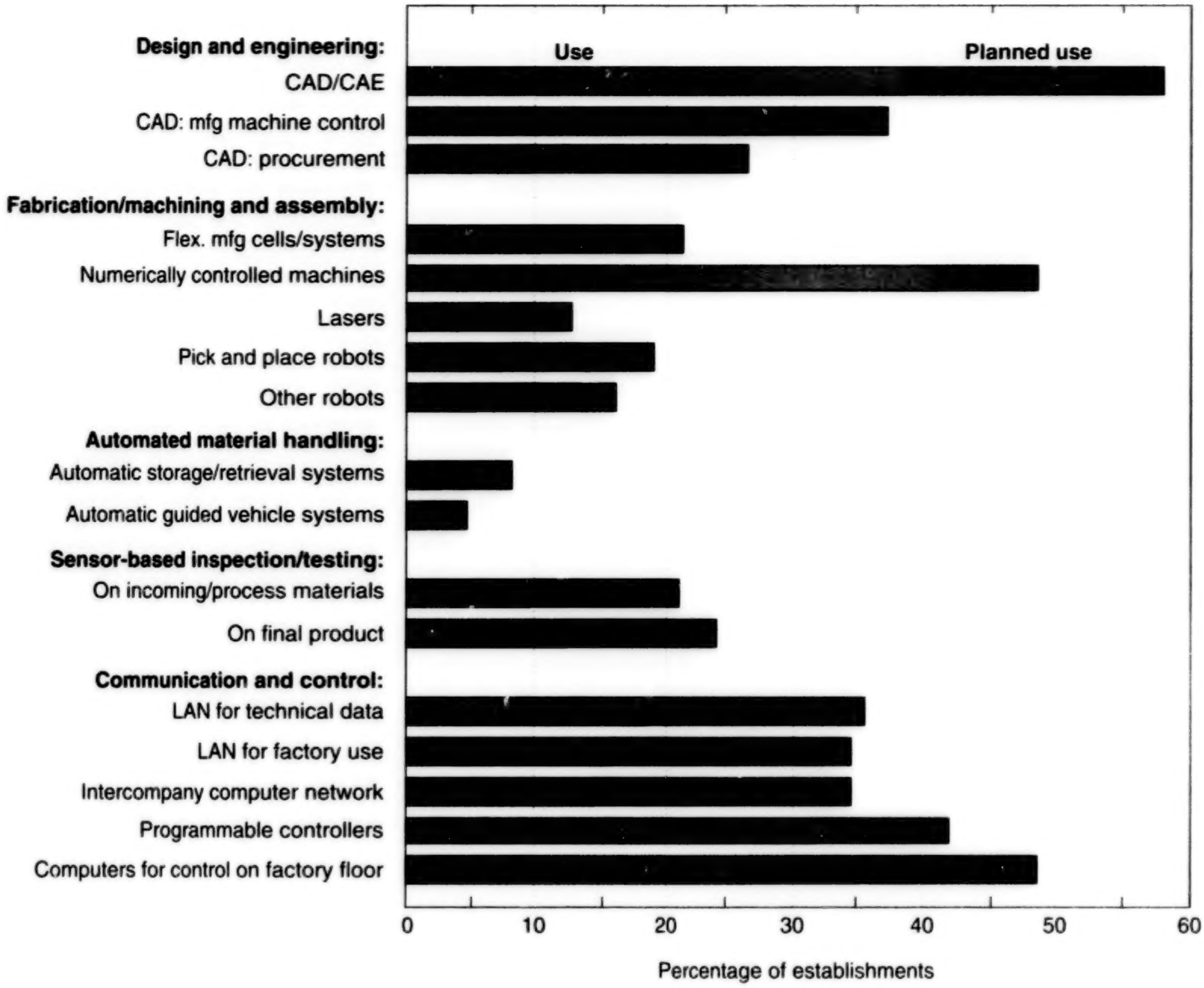
[40] The U.S. survey defined *large plants* as establishments with 500 or more employees and *small plants* as establishments with under 100 employees.

[11] The Canadian survey was conducted in March 1989 as part of a monthly industry survey. It was Canada's second survey of manufacturing technology use and covered the use of 22 advanced technologies (the first 17 are those used in the U.S. survey) by manufacturing plants in Canada. The Australian survey, also conducted in 1989, questioned manufacturers' "acquisition" rather than "use" of 19 advanced technologies (17 of these are comparable to those in the U.S. survey). Unlike the U.S. and Canadian surveys, which excluded manufacturing plants that employed fewer than 20 people, the Australian survey included smaller manufacturers and excluded only those employing fewer than 10.

Another possible source of bias to be aware of in comparing the findings of the three surveys is the differences in sample universes. The U.S. survey sampled establishments from five SICs which included many high-tech industries; Australia and Canada surveyed all manufacturers.

[12] This difference may simply be due to differences in the sampled populations of the three surveys.

Figure 6-22.
U.S. manufacturers' use and planned use of advanced technologies



See appendix table 6-34.

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the most widely used of the 17 advanced technologies in Canada, with eventual use by 29 percent of manufacturers. When asked which of the 17 technologies they planned to use in the next 5 years, Canadian manufacturers—like their U.S. counterparts—selected computers for control on the factory floor.[43]

For all 17 advanced technologies common to the three surveys, Australian manufacturers reported acquisition significantly below the use reported by U.S. manufacturers.[44] The programmable electronic controller had the highest acquisition rate of any of the technologies included in the Australian survey: 14 percent of manufacturing establishments had this technology. CAD/CAE technology also had a relatively high acquisition rate. This technology topped the list for purchase over the next 5 years, which would make it the most prevalent technology in Australian manufacturing.

The U.S. and Canadian surveys solicited information on reasons why manufacturers did not use those advanced technologies that they reported least frequently. (See appendix table 6-35.) Both U.S. (54 percent) and Canadian (79 percent) manufacturers stated that materials working lasers were not applicable to their particular manufacturing operations. In Canada, pick and place robots were cited as not providing enough benefits to outweigh the cost of their incorporation into manufacturing operations. U.S. manufacturers provided the same reason for non-use of automatic guided vehicle systems.

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[43] As noted earlier, the Canadian survey questioned manufacturers on 22 advanced technologies. Two manufacturing information systems technologies that did not appear on the U.S. survey were selected most often by Canadian manufacturers as the technologies they planned to use in the future. These two were followed by computers for control on the factory floor.

[44] Again, the Australian survey included smaller firms than did the U.S. and Canadian studies. It also differed by surveying *acquisition* of advanced technologies rather than *use*.

Finding skilled personnel to work in manufacturing operations that are becoming increasingly sophisticated technologically is a problem often reported by U.S. industry. Information from the Canadian and Australian surveys showed that manufacturers in these countries also had difficulty hiring employees with the skills needed to operate and maintain advanced technologies.[45] In Canada, 53 percent of the surveyed establishments reported having at least some difficulty in hiring skilled personnel to work with the technologies being incorporated into their manufacturing operations; 35 percent of the Australian respondents voiced a similar concern. Manufacturers in both countries made up for this shortfall by providing formal training to their employees. Canadian plants provided in-house training on site or elsewhere in the firm; Australian plants provided existing staff with on-the-job training, special in-house training courses, and external training courses.

Small Business and High Technology

Small business is widely viewed as the source of many of the new products and processes introduced into the economy.[46] Surveys show that small businesses rely more heavily on new products to generate revenues than do larger businesses; consequently, they must be more efficient at producing commercially successful innovations. A keen receptivity to new product ideas found outside their own operations characterizes this efficiency (see Hanson 1991). Small businesses supplement internal product development with new product ideas drawn from dealings with customers, suppliers, government labs, universities, and others to ensure useful innovations. The creation and growth of small high-tech companies are of particular interest as they contribute to the Nation's ability to develop, adopt, and diffuse new technologies.

This section presents certain characteristics and performance indicators for small high-tech companies.[47] The discussion focuses on companies active in the following seven technology fields:

- Automation,
- Biotechnology,
- Computer hardware,
- Advanced materials,
- Photonics and optics,
- Software, and
- Telecommunications.

These fields encompass many of the technologies considered critical to the country's future economic competitiveness. (See "Technologies for Future Competitiveness," pp. 160-62.)

Trends in New U.S. High-Tech Business Startups

The formation of high-tech companies was strongly accelerated during the second half of the 1970s and the early 1980s; this was followed by a sharp decline in formations in the late eighties.[48] (See figure 6-23.) About half of the new high-tech businesses formed during these two decades were computer-related companies; startups in factory automation and telecommunications followed. The number of new biotechnology companies formed during this period trailed the other six technologies, yet it was the only group that increased steadily as a share of all technology company formations. Other technology fields that exhibited relative share growth during the latter half of the 1980s were companies in the advanced materials and photonics and optics fields.

Distribution of Companies by State

New high-tech companies are highly concentrated: Over 65 percent of these companies are located in just 10 states. (See figure 6-24.) Yet compared to just 2 years ago, the distribution appears to be leveling off, with the top three states—California, Massachusetts, and New York—all experiencing share declines (see NSB 1989, p. 364).

These declines notwithstanding, California leads all states by significant margins in six of the seven technology fields examined. Maryland stands out in the biotechnology field, ranking second among the 50 states. The presence of the National Institutes of Health and Johns

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[45] The U.S. survey did not include a comparable question.

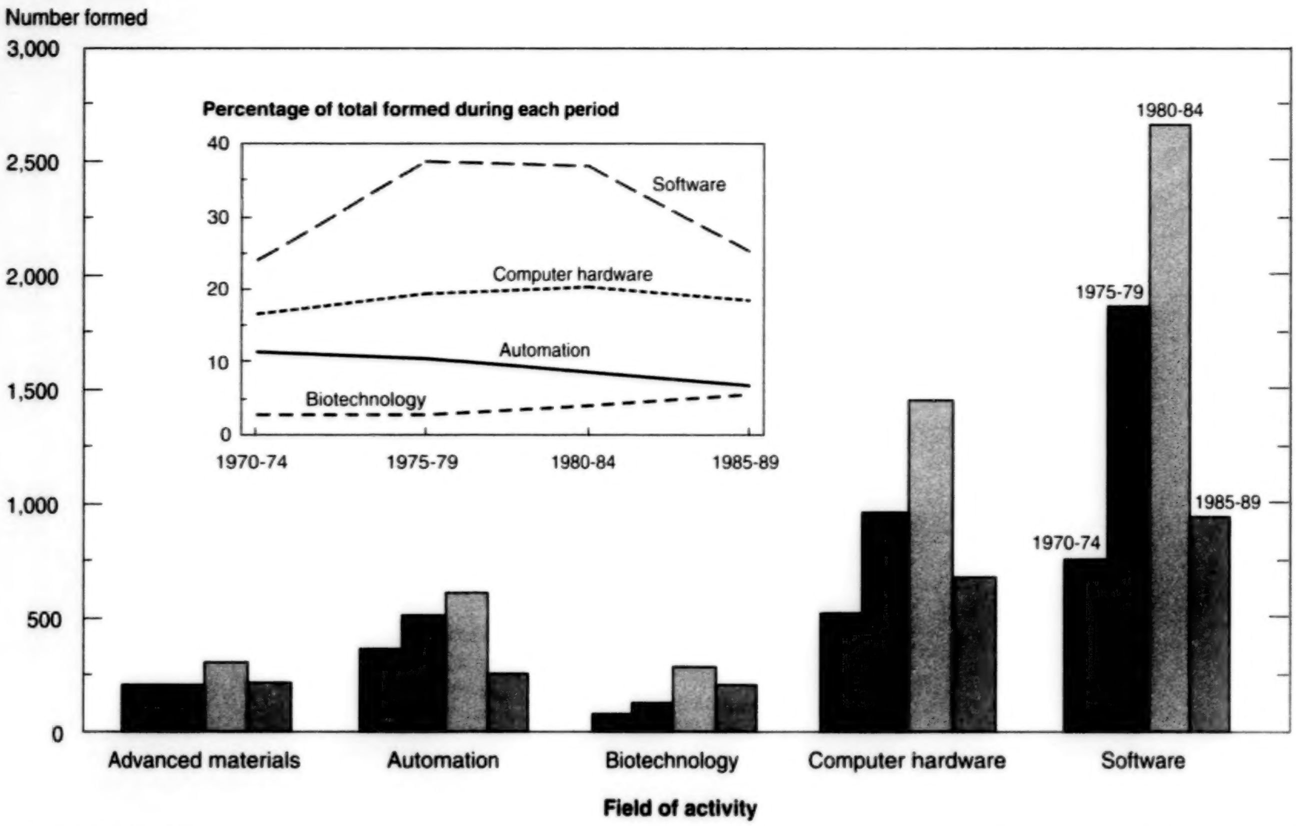
[46] In a 1982 study done for the Small Business Administration comparing innovation between small and large firms, it was found that, per employee, small firms produced 2.4 times as many innovations as large firms. See Futures Group (1984) and Hanson, Stein, and Moore (1984).

[47] Information in this section is derived from the CorpTech data base, owned by Corporate Technology Information Services, Inc., Wellesley Hills, Massachusetts. The CorpTech data base permits an inspection of small business entities by technology field. This data base includes many of the new startups and private companies often missed by other data bases and is one of the most current sources of information on small newly formed companies active in high-tech fields. The data base attempts to be all-inclusive: by CorpTech's own estimate, it includes 99 percent of large companies (over 1,000 employees), 75 percent of medium-sized companies with 250 to 1,000 employees, and 65 percent of companies with less than 250 employees. When prospective companies for inclusion in the data base are identified, they are sent questionnaires covering their size, status (private or public, independent, subsidiary, or joint venture), year formed, and product groups in which they are active. The version of the data base used here (Rev. 6.0 1991) includes about 35,000 independently managed companies.

[48] Throughout this discussion, the following terms are used (see SBA 1988):

- *Establishment or company*—a business entity that may or may not be part of a larger complex, and
- *Firm or enterprise*—an establishment that is either (1) a single location with no subsidiary or branches or (2) the topmost parent of a group of establishments.

Figure 6-23.
High-tech business formation



See appendix table 6-36.

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Hopkins University creates an environment in Maryland conducive to new business formations in the biotech field. Illinois and Ohio tend to attract companies active in factory automation technologies, probably reflecting the Midwest's manufacturing tradition.

Foreign Ownership of U.S. High-Tech Companies

Approximately 11 percent of the high-technology companies are under foreign ownership—up from 9 percent just 2 years ago (see NSB 1989, p. 365, appendix table 6-16). (See appendix table 6-38.) The United Kingdom has, by far, the largest U.S. presence, followed by Japan and West Germany. Although these three countries own companies active in each of the seven technology fields examined, they each tend to be drawn to certain fields: the United Kingdom and West Germany to U.S. companies active in the development of advanced materials, and Japan to companies involved in telecommunications and computer hardware. Compared with the major industrialized countries, Taiwan and South Korea own relatively few U.S. high-tech companies; they have concentrated their acquisitions on U.S. companies active in computer hardware development.

Sources of Capital

The creation and expansion of small business require access to capital. New small businesses engaged in the development of cutting edge technologies can find it difficult to secure traditional financial support—i.e., obtaining bank loans or selling equity in the stock markets. An overwhelming majority (70 percent) of the high-tech companies formed during the 1980s relied solely on private investment for business startup or expansion.[19] (See figure 6-25.) Private investment, in fact, is the primary funding source for each of the technology fields examined. A combination of private investment and venture capital ranked second among the companies, but only 11 percent financed operations in this manner. About 6 percent of the companies were financed solely with venture capital; companies active in telecommunications technologies led the other six fields in using this form of financing.

Performance of New High-Tech Companies

The performance of high-technology companies slowed during 1990, yet they continued to outperform

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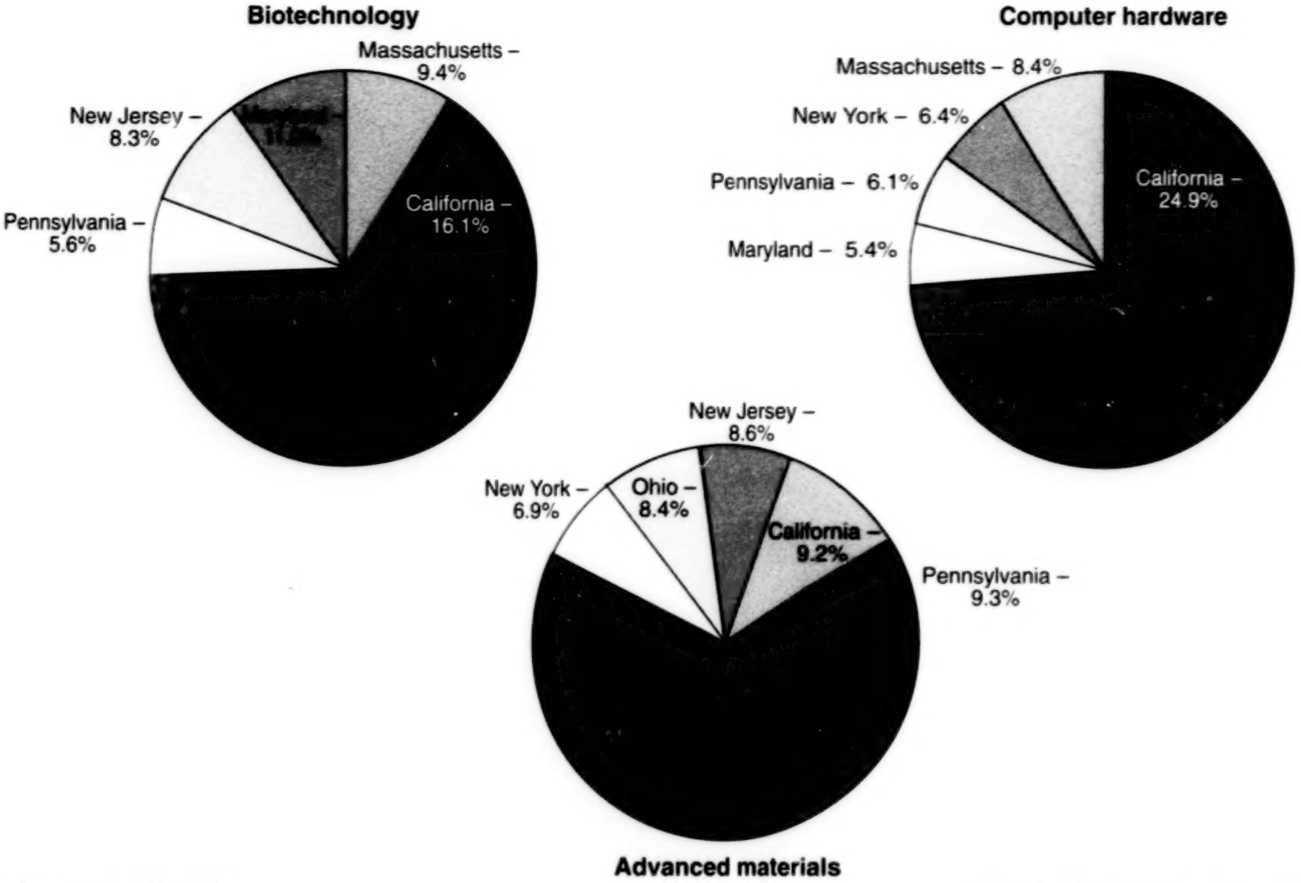
[19] Private investment includes capital provided by principals of the company and by outside private individual investors.

Figure 6-24.
U.S. locations of companies active in three technology fields



See appendix table 6-37.

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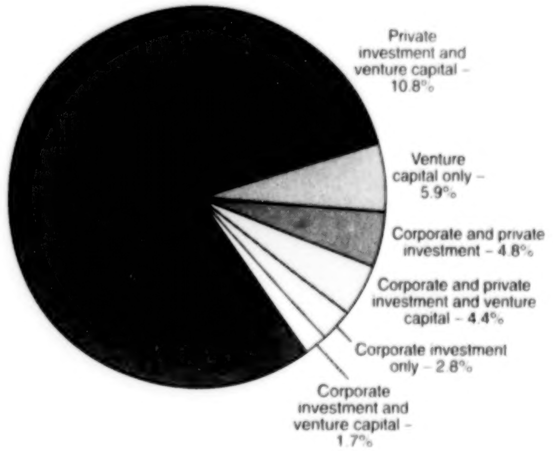
other sectors of the economy (see Corporate Technology 1991, p. 1-viii). High-tech companies formed during the 1980s showed their importance to the U.S. economy by their performance in four indicators—employment growth, job creation, annual sales, and sales exports. (See text table 6-3.) Computer-related companies experienced the highest growth rate of the seven technology fields during 1990, increasing employment by about 14 percent and adding over 250,000 new jobs. Businesses developing computer hardware did somewhat better than the software companies.

The 1990 earnings recorded by these newly formed high-tech companies suggest an ability to generate high revenues even during sluggish economic periods as well as a capacity to offer products that meet the demands of the global marketplace. Annual sales productivity per employee ranged between $86,000 for biotech companies up to $173,000 for companies producing computer hardware. About 40 percent of these new companies generated over 10 percent of their revenues from sales to foreign markets. The advanced materials field had the highest

Figure 6-25.
Sources of capital for new high-tech companies



See appendix table 6-39.

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percentage of companies involved in exporting (44 percent); the software field had the lowest (32 percent). Software suppliers may be somewhat less aggressive than other high-tech companies in seeking out foreign customers, in part because of persistent international disagreements surrounding the rules governing intellectual property rights (see ITA 1991, p. 28-15).[50]

Technologies for Future Competitiveness

Several recent U.S. Government reports (National Critical Technologies Panel 1991, Technology Administration 1990, and DOD 1989) linked future U.S. economic and national security with the timely development and deployment of certain key technologies. Although these reports generally agree on the technology fields on which the United States needs to focus its attention, they differ in certain instances by the technologies emphasized within each field. (See text table 6-4.) This section focuses on the 12 emerging technologies singled out by the Department of Commerce as crucial to this Nation's future industrial competitiveness (Technology Administration 1990).These 12 technologies are categorized into four major areas—materials, electronics and information systems, manufacturing systems, and life sciences applications—and have an estimated potential for $1 trillion in annual product sales in the global market by 2000.[51]

Figure 6-26 summarizes the comparative condition of the U.S. effort, as seen by the Department of Commerce, in each of the 12 technologies vis-à-vis the positions of Japan and the European Community. Briefly, as of 1989, the United States was considered to be ahead of or even with Japan in 7 of the technologies and ahead of or even with Europe in 11. The United States was considered the world leader in five technologies—artificial intelligence, biotechnology, high-performance computing, medical devices and diagnostics, and sensor technology; it lagged behind both Japan and Europe in just one area—digital imaging technology.

However, according to DOC's Technology Administration (1990), if current trends continue, the United States could lose its leadership position to Japan and Europe in many of these technologies by the year 2000. (See figure 6-26.)

Text table 6-3.
Performance measures for newly formed companies active in certain high-tech fields: 1990

Field	Employment growth rate during past year	Number of jobs created during past year	Annual sales per employee	Percentage of companies exporting over 10 percent of total sales
Automation	12.6	58,471	$126,330	40.7
Biotechnology	10.6	16,468	86,063	43.9
Computer hardware	14.5	148,304	172,752	42.9
Computer software	13.9	103,479	107,992	32.1
Advanced materials	5.8	32,452	155,198	44.4
Photonics and optics	8.4	27,654	103,592	36.8
Telecommunications	12.7	61,280	117,679	43.9

NOTE: Includes independent companies formed during 1980-89.

SOURCE: Derived from the CorpTech data base (Rev. 6.0 1991), Corporate Technology Information Services, Inc., Wellesley Hills, MA.

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[50] In fact, copyright protection for software is a high-priority issue in the ongoing negotiations toward the economic integration of Europe. As of the end of 1990, this issue remained unresolved.

[51] An emerging technology is defined as ". . . one in which research has progressed far enough to indicate a high probability of technical success for new products and applications that might have substantial markets within approximately 10 years." DOC's Technology Administration identified its list of critical emerging technologies through consultations with scientists and engineers at the National Institute of Standards and Technology, analysts at DOC's International Trade Administration, and various U.S. science, engineering, and industrial experts.

This section focuses on the DOC list rather than those compiled by the Department of Defense or the National Critical Technologies Panel primarily because the DOC list (1) focuses on technologies with a *commercial* importance, (2) provides international comparisons with Japan and Europe by technology, and (3) overlaps most of the technologies contained on the other two lists.

Text table 6-4.
Comparison of government lists of important technologies

National critical technologies	Commerce emerging technologies	Defense critical technologies
Materials		
Materials synthesis and processing	Advanced materials	Composite materials
Electronic and photonic materials	Advanced semiconductor devices Superconductors	Semiconductor materials and microelectronic circuits Superconductors
Ceramics Composites High-performance metals and alloys	Advanced materials	Composite materials
Manufacturing		
Flexible computer-integrated manufacturing	Flexible computer-integrated manufacturing	
Intelligent processing equipment	Artificial intelligence	Machine intelligence and robotics
Micro- and nanofabrication		
Systems management technologies		
Information and communications		
Software	High-performance computing	Software producibility
Microelectronics and optoelectronics	Advanced semiconductor devices Optoelectronics	Semiconductor materials and microelectronic circuits Photonics
High-performance computing and networking	High-performance computing	Parallel computer architectures
High-definition imaging and displays	Digital imaging	Data fusion
Sensors and signal processing	Sensor technology	Data fusion Signal processing Passive sensors Sensitive radars Machine intelligence and robotics
Data storage and peripherals	High-density data storage	Photonics
Computer simulation and modeling	High-performance computing	Simulation and modeling Computational fluid dynamics
Biotechnology and life sciences		
Applied molecular biology	Biotechnology	Biotechnology materials and processes
Medical technology	Medical devices and diagnostics	
Aeronautics and surface transportation		
Aeronautics		Air-breathing propulsion
Surface transportation technologies		
Energy and environment		
Energy technologies		
Pollution minimization, remediation, and waste management		
		No national critical technologies counterpart: high energy density materials, hypervelocity projectiles, pulsed power, signature control, weapon system environment

NOTE: National critical technologies were designated by the National Critical Technologies Panel; emerging technologies were designated by the Department of Commerce; defense critical technologies were designated by the Department of Defense.

SOURCE: National Critical Technologies Panel, *Report of the National Critical Technologies Panel* (Washington, DC: 1991).

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Figure 6-26.
U.S. report card: 1989 status and trends

	Versus Japan	Versus Europe
Status		
Behind	Advanced materials Advanced semiconductor devices Digital imaging High-density data storage Optoelectronics	Digital imaging
Even	Superconductors	Flexible computer-integrated manufacturing Superconductors
Ahead	Artificial intelligence Biotechnology Flexible computer-integrated manufacturing High-performance computing Medical devices and diagnostics Sensor technology	Advanced materials Advanced semiconductor devices Artificial intelligence Biotechnology High-density data storage High-performance computing Medical devices and diagnostics Optoelectronics Sensor technology
Trends		
Losing Badly	Advanced materials Biotechnology Digital imaging Superconductors	Digital imaging Flexible computer-integrated manufacturing
Losing	Advanced semiconductor devices High-density data storage High-performance computing Medical devices and diagnostics Optoelectronics Sensor technology	Medical devices and diagnostics
Holding	Artificial intelligence Flexible computer-integrated manufacturing	Advanced materials Advanced semiconductor devices High-density data storage Optoelectronics Sensor technology Superconductors
Gaining		Artificial intelligence Biotechnology High-performance computing

SOURCE: Technology Administration, Department of Commerce, "Emerging Technologies: A Survey of Technical and Economic Opportunities" (Washington, DC: DOC, 1990).

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Chapter 7
Attitudes Toward Science and Technology: The United States and International Comparisons

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Attitudes Toward Science and Technology: The United States and International Comparisons

HIGHLIGHTS

U.S. Public Attitudes Toward Science and Technology

- **Most Americans have a positive attitude about science and technology (S&T).** For over 30 years, at least four out of five American adults have stated that S&T has a positive effect on their lives. *See pp. 174-76.*

- **Americans trust the motives of scientists.** Eighty percent agree that most scientists want to make life better for the average person. *See pp. 176-77.*

- **Americans support Federal funding of basic research.** Four-fifths agree with the proposition that even if it brings no immediate benefits, basic scientific research should be supported by the Federal Government. *See p. 177.*

- **Assessments of space exploration are changing, and in a negative direction.** Between 1985 and 1990, the proportion of Americans who felt that the costs of the space program exceed its benefits increased from 38 to 47 percent. *See pp. 177-79.*

- **Fewer Americans now approve of using large animals in scientific research.** Between 1985 and 1990, the percentage who approved of research causing pain to animals like dogs and chimpanzees—even if it results in new knowledge about human health—fell from 63 to 50 percent. *See p. 181.*

U.S. Public Attitudes Toward Education

- **The U.S. public sees strong links between education, advancements in science, and U.S. economic competitiveness.** Seventy-five percent of the public feels that if more Americans could obtain a college degree, "big improvements" would result in science, medicine, and technology; 59 percent predict big improvements in U.S. competitiveness. *See pp. 179-80.*

- **Americans are increasingly concerned about the quality of science and mathematics education.** Since 1985, the percentage of adults who agree that science and mathematics education in U.S. schools is inadequate has risen from 63 percent to 72 percent. *See pp. 179-80.*

International Comparisons of Attitudes Toward S&T

- **Public attitudes toward S&T are reported in this volume for 15 countries.** In 1989 and 1990, coordinated surveys were conducted in Japan, Canada, the United States, and 12 countries of the European Community. *See pp. 182-84.*

- **U.S. and Canadian adults are similar in their attitudes toward S&T and are more positive in these attitudes than Western European adults.** They are also more positive about the impacts of science. *See pp. 184-85.*

- **Notable differences in public support for governmental funding of basic research are evident among the national populations of Western Europe and the United States.** U.S., British, and French respondents were in strong agreement that government should support basic research. In contrast, only a bare majority of adults in West Germany agreed with this proposition. *See pp. 184-85.*

- **The Japanese seem less positive about S&T than Americans, but the indicators are unclear.** Larger percentages of Japanese than Americans disagree that S&T has positive effects on life. On other indicators, Japanese attitudes toward S&T are positive. *See pp. 185-86.*

- **Japanese and American respondents are similar in their assessments of the effects of science on moral issues.** About a third of the adults in each country are concerned that science has a negative effect on morals. *See p. 186.*

Knowledge of Basic Facts About S&T

- **U.S. response patterns for several true/false questions about S&T are similar to Canadian and European (total) responses.** Mean accurate response rates are very similar, and similar distributions within the samples are also evident. Among the member countries of the European Community, however, there are considerable differences in both accurate response rates and distribution of such responses in the populations. *See pp. 187-89.*

Perception of International Standing in S&T

- **Americans increasingly feel that the Japanese are ahead of the United States in basic scientific achievements.** Between 1985 and 1990, the proportion of adults placing Japan ahead of the United States in basic science increased from 29 to 50 percent. *See pp. 189-90.*

- **Americans today are less concerned about Soviet military technology than they were 5 years ago.** Between 1985 and 1990, the proportion of Americans considering the United States ahead of the Soviet Union in military technology increased from 33 to 46 percent. Americans with more education tended to be even more critical in their evaluations of Soviet military technology. *See p. 190.*

Introduction

Chapter Focus

A substantial majority of Americans value scientific research, and they perceive a strong link between advances in science and technology (S&T) and improvements in their own daily lives. Even if they are unsure about the actual processes of scientific work, Americans are positive about the institution of science, about scientists, and about government support for research. American optimism about science stands out among the industrialized countries; compared with Canada, Japan, and the nations of Western Europe, the United States scores high on a set of indicators of public confidence in science.

The U.S. public has maintained its strong support for science while remaining unaware of basic scientific concepts about the natural world. Most adults are not conversant with the broad scientific questions underlying a number of contemporary public policy issues. They often reject scientific explanations that disagree with other beliefs, and their otherwise strong support for science is more equivocal when scientific and moral questions conflict.

Americans are increasingly concerned about the quality of education in the United States and overwhelmingly favor more training in science and mathematics. And, in response to rapid global political and economic changes, the U.S. public is changing its perceptions of the country's world standing in S&T. A majority of American adults now think that Japan leads the United States in both technological development ***and*** basic scientific achievement, while evaluations of Soviet scientific and technological capabilities have dropped sharply.

Chapter Organization

This chapter discusses indicators of these and related topics using data from a series of attitudinal surveys commissioned for this and previous *Indicators* reports.[1] The chapter is divided into two sections. The first contains indicators for the United States only and emphasizes trends over time. This section also contains an expanded discussion of U.S. public attitudes toward issues concerning education and includes a new scale of science and mathematics coursetaking. Many of the data displays show the different response rates for people with varying levels of formal training in science and mathematics.

The second section of this chapter discusses greatly expanded international comparisons on several of the indicators introduced earlier in the chapter. These comparisons are possible because of the rapidly growing number of researchers and sponsoring organizations around the world interested in public attitudes toward S&T.

U.S. Public Attitudes Toward S&T

Many of the following indicators of U.S. public attitudes toward S&T have been collected over the 20-year history of *Indicators* at roughly 2-year intervals.[2,3] The information is organized around these three major questions:

- Who is interested in and attentive to issues concerning S&T, and how does the adult public learn about these aspects of the culture?
- What does the public know about science, including knowledge of scientific concepts, of basic scientific findings and theories, and of current public policy issues involving S&T?
- What are public attitudes toward S&T, that is, how does the public evaluate various aspects of organized science, the effects of science on their daily lives, and large public technology programs?

Who Is *Interested* in Science?

In a modern society rich with information, people tend to specialize in the subjects they pay attention to. They also tend to use different media to learn about current affairs, and these habits of media use differ by level of education, age, and gender. Only television seems to be used by virtually all adults as a source of information about current affairs.

The following discussion focuses on adult Americans who tend to pay attention to scientific and technological matters and how these particular Americans differ from people who are more interested in other types of issues.[4]

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[1] The most recent U.S. survey was conducted in September and October 1990. See footnote 3 and "Availability of Data," p. 183.

[2] In a few cases, the measures extend back to 1957—just before the launching of Sputnik—to a study sponsored by the National Science Writers Association (Survey Research Center 1958). From 1979 through 1990, the survey data in this chapter are largely from Miller (1991a), and many of the concepts in this chapter were first proposed by Miller and Prewitt (1979) and by Miller, Prewitt, and Pearson (1980) under the sponsorship of the National Science Foundation. Miller (1991b) has since modified and expanded certain of these concepts.

[3] The 1990 *Indicators* survey of 2,033 adults was performed, by telephone, from the Public Opinion Laboratory of Northern Illinois University. The response rate was 65 percent. The results of a survey of this size are certain at ±3 percent at the 95-percent confidence level—that is, of all possible samples of this size, responses would be within 3 percentage points of those reported here 95 percent of the time. Uncertainty for subsamples in this chapter would be somewhat greater. In the interests of space, confidence intervals of the data are not discussed here. The technical report for the 1990 survey and an integrated codebook from the five *Indicators* surveys are available (Miller 1991a and 1991b). See "Availability of Data," p. 183.

[4] This section discusses only six issue areas from the *Indicators* survey. (See text table 7-1.) The survey also asks about interest in and knowledge of international and foreign policy, economic issues and business conditions, military and defense policy issues, local school issues, and agricultural issues. For responses on these items, see appendix tables 7-1 and 7-2 and Miller (1991a).

The section presents the following three sets of indicators comprising different aspects of attentiveness:

- *Interest* in different sets of issues,
- *Level of information* about the sets of issues, and
- *Exposure to media* where learning about the issues might occur.

These indicators are then combined in indexes of "attentiveness" to scientific and other subjects.

Interest in News About S&T. The first aspect of attentiveness is a measure of interest in different sets of issues. Like most of the other indicators in this chapter, interest in news issues involving new scientific discoveries remained relatively stable over the past decade: between 37 and 48 percent of people surveyed acknowledged a high interest. In 1990, 39 percent of U.S. adults said they were very interested in new scientific discoveries, and nearly 9 out of 10 were either "moderately" or "very" interested in these discoveries. (See appendix table 7-1.)

Compared with the 39 percent of respondents who say they are "very" interested in scientific discoveries and new inventions and technologies, larger percentages report being very interested in other issue areas, notably environmental pollution, military and defense policy, and new medical discoveries. (See figure 7-1.)

Medical discoveries and environmental pollution held the interest of significant percentages of Americans; about two-thirds of the adult population were "very" interested in these news items. In contrast, only about one-fourth of U.S. adults reported that they were "very" interested in space exploration, and a similar proportion was "not at all" interested in space exploration. This was the highest percentage reporting no interest in any of the issue areas. (See "Assessments of Three Technology Programs," p. 177-79.)

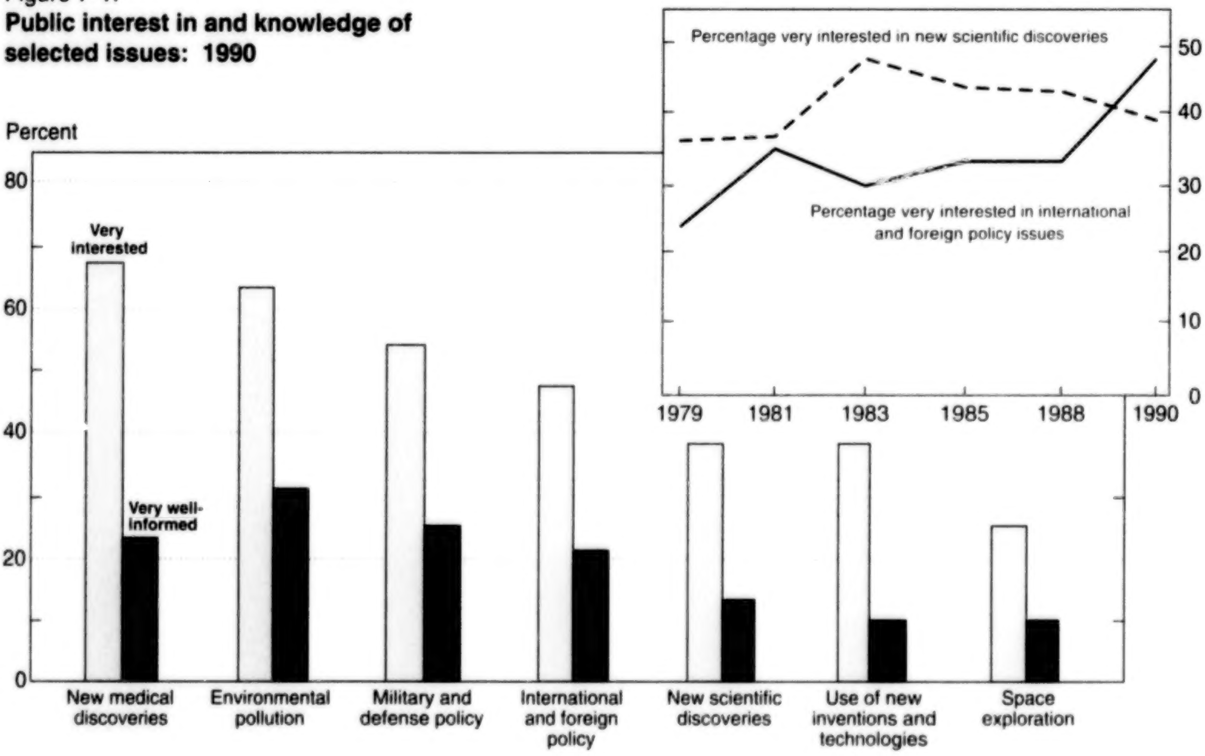
The percentages of Americans who were very interested in military and defense policy and in international and foreign policy were up sharply in 1990 over 1988. (See appendix table 7-1.) The 1990 survey was conducted in October and November, just after the Iraqi invasion of Kuwait and concomitant with the buildup of U.S. troops in Saudi Arabia. (See also footnote 20.)

Level of Information About S&T. A second important aspect of attentiveness is a level of knowledge about the subject of interest. In contrast with their expressed high levels of interest in sets of news issues, American adults were less confident about their levels of knowledge of these subjects. Fewer than a third of adults felt very well-informed about *any* of the sets of issues, and as many as a third or more felt *poorly* informed about several.

A third of U.S. adults felt very well-informed about issues involving environmental pollution. On all of the other issues shown in appendix table 7-2, a quarter or fewer of U.S. adults felt very well-informed. Most judged their knowledge of issues to be "moderate."

Many Americans were pessimistic about their knowledge of some matters involving S&T but were more con-

Figure 7-1.
Public interest in and knowledge of selected issues: 1990



See appendix tables 7-1 and 7-2.

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fident about others. Over 30 percent felt poorly informed about new scientific discoveries, 35 percent about new inventions and technologies, and 38 percent about space exploration. In contrast, only 20 percent felt poorly informed about new medical discoveries and 13 percent about environmental pollution. These contrasting response patterns on subjects with considerable S&T content are mirrored in the different demographic characteristics of the groups that pay attention to specific sets of subjects.

Media Exposure to S&T. The third facet of attentiveness is a habit of exposing oneself to media where learning about issues might occur. The general population, not otherwise predisposed to seek exposure to science, might learn about S&T in the popular media: television, newspapers, and magazines. Newspapers have especially increased their coverage of science- and health-related topics over the past decade, often in special sections devoted to these articles (NSB 1987). More focused exposure to scientific information might be gained from science magazines, from television shows like "Nova," or from visits to such public places as natural history museums, S&T museums, zoos, and aquariums.

To gauge the extent of such contacts with S&T issues, the *Indicators* survey asks respondents about their habits in

- Reading,
- Television viewing, and
- Museum attendance.

About 57 percent of adults reported reading a daily newspaper, and men were somewhat more likely than women to use this source of information. (See appendix table 7-3.) Daily newspaper readership is also strongly correlated with increasing age. (See figure 7-2.) Older adults were about twice as likely as younger adults to read a daily newspaper. Also, older people were more attentive to new medical discoveries than were other groups. This characteristic of the newspaper reading population may help explain the growth in special health sections in U.S. newspapers (reported in NSB 1987), even though daily newspaper reading by the general population has been declining for several decades.[5]

Education level is positively related to daily newspaper reading, and even more strongly to reading of national newsmagazines and science magazines. Adults who have graduated from college were almost four times as likely as those who had not finished high school to read newsmagazines; they were three times more likely to read science magazines regularly. (See figure 7-3.) Using these specialized sources of information is somewhat related to increased age, but only up through the 45- to 64-year-old age group; beyond these ages, general newsmagazine and science magazine readership drops sharply. (See figure 7-2.) Women were less likely than men to read science magazines: 81 percent stated that they never use this medium versus 66 percent of men.

Education level has virtually no effect on the likelihood of watching both television news and science shows.[6] (See figure 7-3.) Age is positively correlated with watching television news and science programs.

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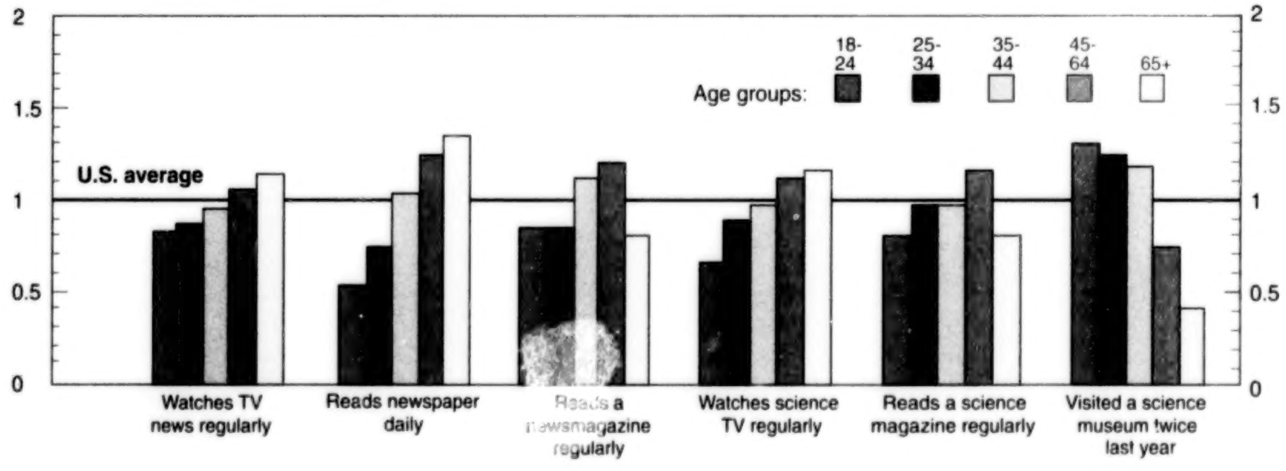
[5] Between 1972 and 1990, daily newspaper readership declined from 69 to 53 percent of the population (NORC annual series).

[6] Television science shows in the survey were defined as "Nova" and National Geographic specials.

Figure 7-2.
Effect of age on media use and museum visits: 1990



NOTE: U.S. average = 1.
See appendix tables 7-3 and 7-4 for absolute values and question wordings.

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Museum visits may result in casual learning about S&T. In 1990, 42 percent of the respondents indicated that they visited a science museum at least twice in the previous year.[7] Among college graduates, 64 percent reported such visits; this was more than three times the likelihood of persons with no high school degree. (See figure 7-3.)

Thus, each of the variables of age, gender, and education level is helpful in predicting the likelihood of exposure to opportunities for informal learning about S&T. As shown above, each of these variables is also identified with select media.

"Attentiveness" to S&T. When considered together, the three sets of indicators discussed above—interest in, level of information about, and media exposure to S&T issues—identify segments of the adult population that are regularly "attentive" to different sets of issues in the news.[8] The *Indicators* series has used the attentiveness concept to distinguish among segments of the adult population that follow public policy matters with significant scientific and technological implications—e.g., nuclear energy policy, new medical technologies, and space exploration. Political leaders are likely to turn to these groups—or their representatives—in the course of setting policy in these areas.

The *Indicators* index of attentiveness to selected issues uses respondents' self-reports on

- *Inclination* to follow certain items in the news—a respondent must state that he or she is "very interested" in an issue area to be labeled attentive to that area;
- *Knowledge* of an area—a respondent must state that he or she is "very well-informed" about an issue area to be labeled attentive to that area; and
- *Behavior* that would expose a person to information about certain issue areas—a respondent must state that he or she is a regular reader of a daily newspaper, a national newsmagazine, or a science magazine to be labeled attentive to any issue area.

Text table 7-1 shows the proportions of adult Americans who meet all three of these criteria on each of six sets of issues.

About 8 percent, or some 14 million U.S. adults, are attentive to new scientific discoveries.[9] Attentiveness to scientific matters is strongly dependent upon educational level, particularly education in mathematics and science. People who are college graduates are more than twice as likely to be attentive to new scientific discoveries, and people with more science and mathematics courses in high school and/or college are more

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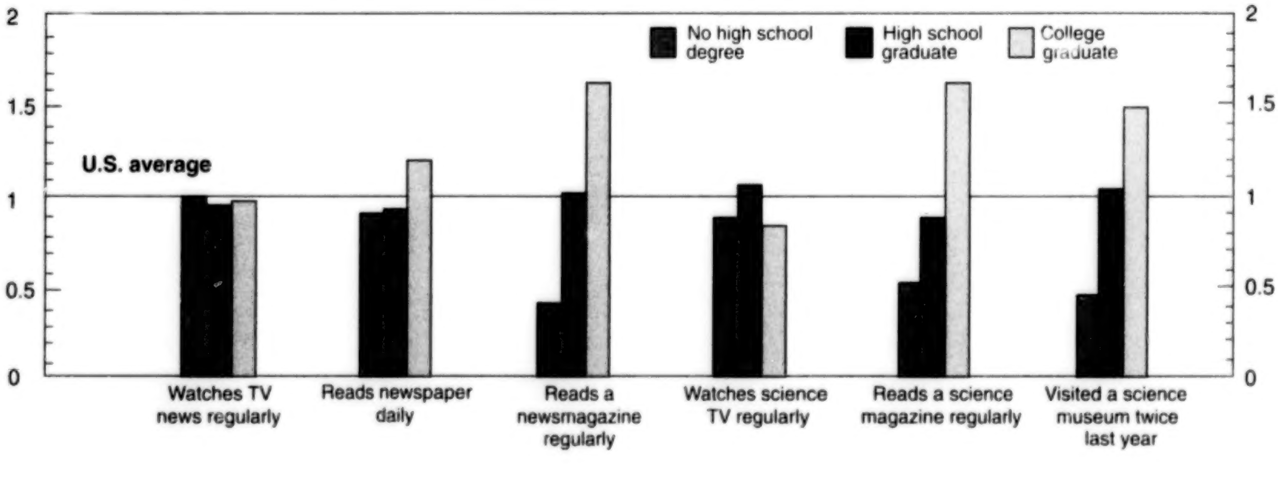
[7] "Science museum" here refers to a science or technology museum, a zoo or aquarium, or a natural history museum, each of which was asked about separately in the survey.

[8] Miller (1991b) has further refined this concept of attentiveness to various issues and has constructed a measure of "attentiveness to science and technology policy" which is a combination of attentiveness to scientific issues and attentiveness to issues involving new technologies.

[9] U.S. population estimates used throughout this chapter are from special tabulations of the Bureau of the Census, Current Population Survey, third quarter, 1990. The population estimates are based on civilians 18 years of age or older, not living in group quarters, and including military personnel living off-base in the United States.

Figure 7-3.

Effect of education on media use and museum visits: 1990



NOTE: U.S. average = 1.

See appendix tables 7-3 and 7-4 for absolute values and question wordings.

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Text table 7-1.
Public attentiveness to news issues, by selected characteristics: 1990

	Attentiveness to . . .						
	New scientific discoveries	New technologies	Nuclear energy	Medical discoveries	Space exploration	Environmental pollution	N
	Percent						
Total public	8	7	8	16	6	20	2,033
Gender							
Male	11	11	12	15	10	23	964
Female	6	4	4	17	3	18	1,070
Degree level							
No high school degree	7	5	7	19	3	15	495
High school graduate[1]	6	7	7	14	6	21	1,179
College graduate	16	12	12	18	11	27	359
Science & math education[2]							
Low	5	5	5	15	4	16	1,263
Medium	9	10	10	14	7	25	523
High	24	17	16	23	17	33	248
Age							
18-24	8	8	5	10	7	19	322
25-34	7	9	4	10	6	16	497
35-44	9	6	7	12	5	19	366
45-64	8	7	9	20	6	23	533
65 and older	9	7	14	28	6	24	315

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see "The Science and Mathematics Education Index," p. 172.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979–1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

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than four times as likely to be attentive to scientific discoveries. (See "The Science and Mathematics Education Index," p. 172.) Men are nearly twice as likely to be attentive to new scientific discoveries as are women.

Between 6 and 8 percent of Americans are attentive to new technologies, nuclear energy, and space exploration. As with attentiveness to science, these groups of the adult public are highly educated compared to the general population, and they are dominated by men. Women seem particularly inattentive to these three areas.

Of the issue groups shown in text table 7-1, much larger percentages of the total adult population are attentive to medical discoveries and environmental pollution; women are more likely to belong to these attentive publics than to others. Older Americans regularly pay attention to medical discoveries, and attentiveness to environmental issues also increases somewhat with age. The effect of education in general disappears for the segment of the population attentive to medical discoveries; however, persons with more courses in science and mathematics are more likely to belong to this attentive group.

The attentive public for environmental pollution is about 20 percent, or 36 million Americans. Members of this attentive public are proportionately more highly educated and older.

In interpreting the various indicators discussed later in this chapter and analyzing the response patterns of the general population versus those of the attentive groups, it is helpful to note the different characteristics of the various attentive groups. People attentive to scientific discoveries or to space exploration are considerably more likely to be highly educated and to have had more science and mathematics courses than nonattentives. Also, although men account for only about 47 percent of the survey sample, they constitute two-thirds of the public attentive to scientific discoveries and over three-quarters of those attentive to space exploration.

The Science and Mathematics Education Index

Many of the tables in this chapter display a cross-cut of the data by high, medium, and low levels of science and mathematics education. Miller (1991b) developed this index from the 1990 *Indicators* survey and has used it to explore variations on a scale of "scientific literacy."

The index was constructed from three sets of questions. First, respondents were asked if they had taken a high school course in biology, chemistry, or physics. Second, they were asked their highest level of mathematics coursework taken in high school. From this second question, a total number of courses of high school mathematics was *inferred* for each respondent based on a typical high school program of mathematics courses: first-year algebra, geometry, second-year algebra, precalculus, and calculus.

Third, respondents who reported having finished high school were asked how many college-level courses in biology, chemistry, or physics they had taken. (Some 70 percent of U.S. adults have never taken a college-level science course.) Typical responses were "one or two" or "15 or 20 courses" for some respondents. For the purpose of index construction, a maximum of 10 college-level science courses were counted for any respondent.

These three estimates (reports of high school and college courses in biology, chemistry, and physics and inferred high school mathematics courses) were then totaled and divided into three levels of courses: low, for four or fewer courses (62 percent of respondents); medium, for five to eight courses, representing a good high school program (26 percent); and high, representing a good high school program and some college coursework (12 percent). (See text table 7-2.)

Men were twice as likely as women to have high exposure to formal science and mathematics education in high school and college; some 70 percent of women in the United States reported low exposure to these courses. Older Americans, especially after age 45, have also had relatively less coursework in science and mathematics. High exposure to science and mathematics in school was most prominent for young adults up through age 44. As this group matures, higher percentages of the total population will be able to report more exposure to formal training in science and mathematics.

Text table 7-2.
Index of science and mathematics education, by gender and age

	Low	Medium	High	N
		Percent		
Total public	62	26	12	2,033
Gender				
Male	53	30	17	964
Female	70	22	8	1,070
Age				
18-24	47	41	12	322
25-34	57	26	17	497
35-44	58	26	16	366
45-64	69	22	9	533
65 and older	80	16	4	315
Attentive publics				
New scientific discoveries	37	27	35	168
New technologies	38	33	29	148
Nuclear energy	43	33	25	157
Medical discoveries	59	23	18	323
Space exploration	36	31	33	123
Environmental pollution	48	32	20	412

NOTES: This index is based on the number of high school science and mathematics courses and the number of college science courses taken. The index includes high school mathematics and high school and college courses in biology, chemistry, and physics; it excludes courses taken in other disciplines or in college mathematics. "Low" is four or fewer courses, "medium" is five to eight courses, and "high" is nine or more courses. Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller, *The Public Understanding of Science & Technology in the United States*, report to the National Science Foundation (DeKalb, IL: Public Opinion Laboratory, Northern Illinois University, 1991); and unpublished tabulations.

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What Do People *Know* About Science?

Since 1979, the *Indicators* studies of public attitudes toward S&T have included indicators of the adult population's understanding of scientific terms and concepts.[10]

Knowledge of Scientific Process. Most respondents have difficulty answering the first question in the short battery of open-ended inquiries about level of knowledge of scientific terms and concepts. This question asks: "In your own words, could you tell me what it means to study something scientifically?" In 1990, 18 percent of U.S. adults gave an acceptable definition of scientific study.[11,12] (See appendix table 7-5.) Significantly higher percentages of people with more education could correctly provide the definition.

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[10] The survey has regularly requested open-ended definitions of "scientific study," "radiation," and "DNA." (Respondents are first asked if they have clear, general, or little understanding of a term. Those reporting little understanding are not asked for the followup definition.) These and other open-ended questions are coded by independent coders at the Public Opinion Laboratory, Northern Illinois University, and tests of intercoder reliability are performed and differences resolved. Multiple-choice questions designed to measure respondents' understanding of the concepts of "probability" and "controlled study" were added in 1988. In 1990, batteries of questions concerning two topical environmental issues—acid rain and the ozone hole—were added.

In addition, as part of ongoing studies of scientific literacy (Miller 1991b) the 1990 survey included a short battery of simple closed-ended questions that are used here to indicate the distribution of elementary scientific knowledge in the adult population. "Knowledge of Scientific Conclusions," pp. 187-89, reports on the use of several of these quiz-type questions for comparisons among the United States, Canada, Japan, and the European Community.

Closed-ended questions concerned with aspects of scientific work elicited much higher correct response rates. For example, when asked a multiple-choice question involving probability, 70 percent of the adult population selected the correct answer. (See appendix table 7-5.) Similarly, 72 percent correctly answered a closed-ended question about controlled clinical trials. These very different rates of correct response on aspects of scientific study suggest that respondents may well know more about science than responses to the open-ended question would indicate.[13]

Knowledge of Environmental Issues. In addition to the items concerning interest in and knowledge about issues involving environmental pollution (see "'Attentiveness' to S&T," pp. 170-71), the 1990 survey included short sets of questions about two timely environmental issues: acid rain and ozone depletion.

When asked to describe acid rain, 6 percent of the adult public was able to give a scientifically correct response. (See appendix table 7-6.) An additional 10 percent was able to name the cause or source of acid rain ("smokestacks," "plants that burn coal," etc.), and 31 percent referred to an unspecified "pollution" for a partially correct response. Higher percentages of respondents with more education—including more science education—were able to describe acid rain correctly, but overall fewer than one in five adults could knowledgeably engage in a conversation about acid rain. Even the attentive public for issues involving environmental pollution was surprisingly ignorant about this widespread and current public policy issue: 40 percent of this group failed to describe the scientific issue correctly, and another 36 percent were able only to identify acid rain with a general concept of "pollution."

A somewhat larger percentage of U.S. adults seemed to grasp the technical aspects involved in producing the ozone hole. One-fourth of the survey respondents gave a correct answer to the question "In your own words, why is there a hole in the ozone layer?"[14] An additional 18 percent mentioned "pollution" as the cause of the ozone hole problem.

Correct responses to this question were strongly related both to gender and level of education. (See appendix table 7-6.) About one-third of male and one-fifth of female respondents were able to identify the ozone hole problem correctly. Forty-five percent of the attentive public for environmental pollution was unable to describe correctly why the ozone hole exists.[15]

The public is also unclear about the *location* of the ozone hole.[16] Only 11 percent could identify the Antarctic, and another 4 percent mentioned both the South and North Poles. As with other questions on the survey, men and people with higher levels of education were more likely to place the ozone hole geographically. Over 90 percent of U.S. adult women did not know the location of the ozone hole.

In sum, 25 percent of the *general* U.S. adult population were able to offer correct information about these two significant public policy issues of environmental pollution. Similar results hold for the public *attentive* to issues involving environmental pollution. The findings suggest that, although these environmental issues cause emotional responses and high levels of concern among adults, this concern is poorly grounded in factual information.

Knowledge of Scientific Concepts. The 1988 and 1990 *Indicators* surveys included short batteries of closed-ended simple questions about S&T to test respondents' knowledge of widely accepted scientific and technological phenomena that they would most likely have learned in primary or secondary school.[17]

Of the 13 questions shown in figure 7-4, about 15 percent of adults could answer half of them correctly. Just over 1 percent answered all of the questions correctly.

Over three-fourths of the respondents knew simple facts about the natural world: that the center of the earth is hot, that plants produce oxygen, that hot air rises, and that light travels faster than sound. Seventy-seven percent agreed with the concept of continental drift.

Respondents had more trouble with several simple questions involving common technologies: 37 percent claimed not to know whether lasers generate light waves or sound waves. And a full 70 percent did not know if

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[11] For coding purposes, responses referring to theory or hypothesis testing, to experimentation, or to thorough study or comparison are considered acceptable definitions. Coded separately, but not accepted as correct, are responses referring to measurement or classification.

[12] Withey (1959) found that 12 percent of American adults had an acceptable understanding of "scientific study" in 1957.

[13] Miller (1991b) uses the open-ended question as one component of scientific literacy. In addition to requiring a correct response on this question, he also requires respondents to reject astrology as having any scientific basis. In 1990, 13 percent of the adult population passed this component of his literacy construct.

[14] "Correct" in this case refers to the ability to describe correctly the roles of chlorofluorocarbons (CFCs) or chlorine atoms in the process of creating the hole, or the ability to identify the technologies—aerosol sprays, refrigerants, and styrofoam manufacturing—that release most of the CFCs.

[15] This finding, and others shown in appendix table 7-6, underlines the need for sensitivity to the differences between *attentiveness* to an issue and *knowledge* of an issue.

[16] This question may also indicate a lack of knowledge of world geography.

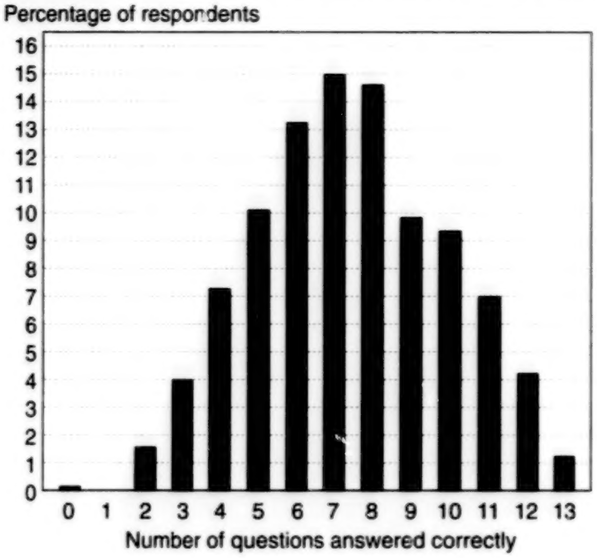
[17] The questions discussed in the following sections were developed by Jon Miller of Northern Illinois University, John Durant of the Science Museum, London, and Geoffrey Thomas of University of Oxford, England. See Miller (1987).

Most of these questions are asked in a true/false format; a "don't know" response is accepted but not offered for every question. Rather, the introduction to the knowledge battery states that "If you don't know or aren't sure, just tell me so, and we will skip to the next question."

A few questions that virtually all respondents can answer correctly are included to bolster respondent confidence. In 1990 these questions included "Sunlight can cause skin cancer" and "Smoking causes lung cancer." Ninety-five percent of U.S. adults over 18 agreed with these statements. These are examples of scientific findings that have become common knowledge; they also underline the extent to which Americans experience S&T through medicine.

Figure 7-4.
Knowledge of 13 scientific conclusions: 1990

Distribution of correct responses in the U.S. population



Responses to individual questions

	Correct	Incorrect	Don't know
1. "The center of the earth is very hot."	79%	7%	14%
2. "The oxygen we breathe comes from plants."	85	10	6
3. "Lasers work by focusing sound waves."	37	26	37
4. "Hot air rises."	95	2	3
5. "Eloctrons are smaller than atoms."	41	24	35
6. "Antibiotics kill viruses as well as bacteria."	30	60	11
7. "The universe began with a huge explosion."	32	33	35
8. "The continents on which we live have been moving their location for millions of years and will continue to move in the future."	77	8	15
9. "Human beings as we know them today developed from earlier species of animals."	45	41	14
10. "The earliest humans lived at the same time as dinosaurs."	47	36	18
11. "Which travels faster: light or sound?"	75	20	6
12. "Does the earth go around the sun, or does the sun go around the earth?"	73	20	7
Asked if question 12 was answered correctly:			
13. "How long does it take for the earth to go around the sun? One day, one month, or one year?"	48	18	33[1]

[1] Includes respondents who could not answer #12 correctly.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

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antibiotics kill viruses, displaying a fundamental misunderstanding of the differences among types of microorganisms and the efficacy of antibiotics in fighting common diseases.

More than half of U.S. adults are confused about very long timespans in the history of the earth: 36 percent agreed that humans lived alongside dinosaurs, and 18 percent did not know the answer to this question.[18]

On questions that might conflict with some religious teachings, the response rates in the 1990 survey show that adults often chose belief over a scientific interpretation of natural history. In the case of evolution, 41 percent rejected the idea that "Human beings as we know them today developed from earlier species of animals"; another 14 percent claimed not to know the truth or falseness of evolutionary theories of human development. In all, then, 55 percent of American adults either rejected outright or were uncertain about the theory of evolution. In a similar vein, when asked about the origin of the universe, 33 percent disagreed that "The universe began with a huge explosion," and another 35 percent claimed not to know.

The motions and timing of the solar system were confusing to many respondents. While 73 percent knew that the earth goes around the sun, only 48 percent knew that this journey takes 1 year. Respondents also have trouble with the atomic world: only 41 percent could answer correctly that "Electrons are smaller than atoms"; 35 percent said they didn't know.

These response patterns indicate that most Americans are not familiar with fundamental scientific theories and do not understand basic characteristics of simple technologies.[19]

On the other hand, one of the clear findings of the *Indicators* studies is that the low level of knowledge of science in the U.S. adult population contrasts sharply with its consistently strong and positive attitudes toward science. Support for S&T among the U.S. population has remained high. Even if some observers are correct in predicting that the low level of scientific knowledge endangers the material progress of the Nation, there is no evidence of a decrease in general public support for the institution of science. So, at least for now, the lack of ***knowledge*** of science may not figure prominently in the public's ***support*** for science and scientists.

What Do People *Think* About Science?

For over 30 years, at least four out of five Americans have stated that science and technology have a positive effect on their lives. These and similar indicators of public attitudes toward S&T are discussed in this section.[20]

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[18] Interpretation of this indicator is problematic, since some creationists also believe that humans and dinosaurs co-existed. Failure to answer this question correctly may thus reflect respondents' lack of ***knowledge*** or lack of ***belief***.

[19] But the extent of U.S. knowledge on these items is generally comparable to that of other countries, as discussed in "Knowledge of Scientific Conclusions," pp. 187-89.

The following paragraphs discuss measures of public attitudes toward research, scientists, and Federal support of scientific research. Attitudes toward three large and visible technology programs are then discussed, followed by a closer look at data indicating the public's attitude toward education and the importance of education for S&T.

Attitudes Toward Scientific Research and Scientists. The *Indicators* survey asks a number of questions designed to measure attitudes of the adult public toward S&T.[21] (See appendix table 7-7.) No single assessment of public attitudes toward S&T is presented in this chapter; it is important that all of the measures be taken together as indicators of an overall public assessment and that no undue significance be attached to any one question.

In 1957, 94 percent of the American public agreed that "Science and technology are making our lives healthier, easier, and more comfortable." Between 1957 and 1979, the percentage agreeing with this claim dropped to the low 80-percent range, but this apparent drop may be an artifact of different survey methodologies. In any case, the percentage agreeing with the statement has not changed in the four surveys since 1979. The very low percentage that either says "don't know" or refuses to answer (from 2 to 3 percent) suggests that respondents are unequivocal when making this assessment.

Respondents also feel that science is important in their own lives. About 85 percent disagree with the statement that "It is not important for me to know about science in my daily life."

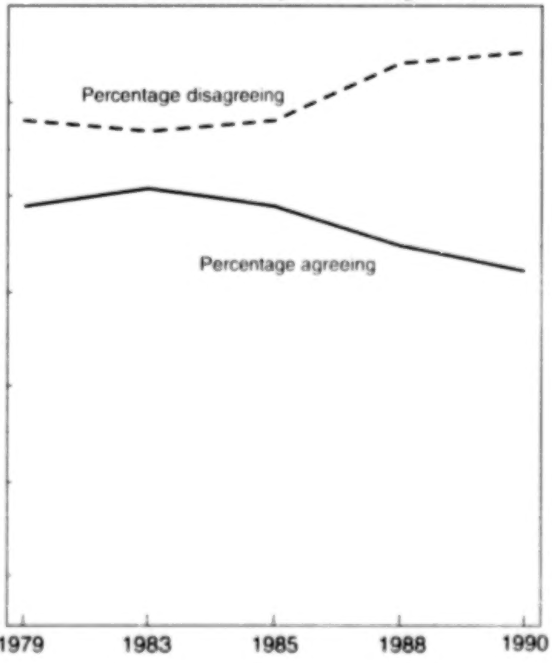
Between 1979 and 1990, decreasing proportions of respondents agreed with the statement that "Science makes our way of life change too fast"—a statement deliberately worded with a negative bias. (See figure 7-5.) In 1990, 60 percent disagreed with the statement, while 37 percent agreed; this represented a shift from 53 percent and 44 percent, respectively, since 1979.

The *Indicators* survey also asks about general attitudes toward scientific research in a more complex formulation. Rather than being presented with a simple agree/disagree choice, respondents are asked to balance positive and negative effects in the question "Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?"[22] (See text table 7-3.)

Figure 7-6 shows the strongly positive responses to this question by gender and education level. Men are more likely than women to have strongly positive

Figure 7-5.
Science and the pace of life

"Science makes our way of life change too fast."



See appendix table 7-7.

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[20] Only people, not nations or other groups, possess attitudes. Hennessy (1972) defines an attitude as a rather enduring orientation toward an object or set of objects. Hennessy sets "attitudes" midway between "opinions" and "belief systems" in his typology:

- *Opinions* are orientations of the moment toward some specific, and passing or contemporary, object;
- *Attitudes* are more diffused orientations toward an object or a class of objects, not necessarily of the moment or controversial, and more stable over time; and
- *Belief systems*, or ideologies, are organizations of integrated opinions and attitudes closely identified with oneself.

Hennessy (p. 38) argues that to have attitudes, an individual must possess "minimal cognitive activity, integrative capacity, and motivational arousal." Based on these criteria, it is likely that few individuals actually possess attitudes toward science.

Miller (1991b) argues that most persons who qualify as attentive to a set of issues actually have attitudes toward those issues. (Note that in this chapter, the idea of an "attitude toward science" refers to an *inference* of an attitude based on survey question responses.)

Many of the response patterns shown here are for the attentive publics and for more highly educated groups of the adult population. It may be assumed that the responses of these groups are more stable and represent more consistent orientations toward the subjects being asked about than would be the case for the rest of the population. In short, responses for attentive and educated persons are more likely to reflect attitudes, not opinions.

An example of the volatility in public opinion is shown in figure 7-13. In the spring of 1980, there was an increase in public opinion noting that too little was being spent on the military. At the time, the Nation was deeply embarrassed over the Iranian hostage crisis, and the Soviets had just invaded Afghanistan. This very strong and short-lived change was probably a strong shift in opinion, not attitudes. The moderately changing response patterns just before and after this shift were probably more reflective of attitudes.

[21] The questions are purposefully designed to tap (1) general attitudes and (2) assessments of more specific aspects of science.

[22] The question is then followed by a probe for degree of harm or benefit: "Would you say that the balance has been strongly in favor of beneficial [harmful] results, or only slightly?" Such probes encourage the respondent to continue to focus on the subject introduced in the first question, and ideally lead to a more considered and thorough response overall from the individual respondent.

Text table 7-3.
Public assessments of scientific research

"Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?"[1]

	1972	1974	1976	1979	1981	1985	1988	1990
	Percent							
Benefits greater. .	70	75	71	70	74	68	76	72
About equal[2]	13	14	15	13	11	4	5	7
Harms greater. . .	8	5	7	11	14	19	12	13
Don't know/ no answer . . .	9	6	7	6	1	8	7	8
N =	2,209	2,074	2,108	1,635	1,536	2,005	1,042	2,033

NOTE: Percentages may not total 100 because of rounding.

[1] 1972-76 wording: "Do you feel that science and technology have changed life for the better or for the worse?"

[2] Volunteered by the respondent.

SOURCES: National Science Board, *Science Indicators - 1972* (Washington, DC: GPO, 1973); *Science Indicators - 1974* (Washington, DC: GPO, 1975); *Science Indicators - 1976* (Washington, DC: GPO, 1977); J.D. Miller, *Public Attitudes Toward Science and Technology, 1979–1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

See appendix table 7-8. *Science & Engineering Indicators – 1991*

attitudes toward scientific research, by about 10 percentage points. Strongly positive evaluations of scientific research also increase sharply with increasing levels of education: college graduates are two to three times more likely to view the benefits of scientific research as "strongly beneficial" than are people without a high school diploma.

The survey also explores people's perceptions of *scientists* by asking respondents to agree or disagree that "Most scientists want to work on things that will make life better for the average person." In the 1985, 1988, and 1990 surveys, 80 percent of the respondents agreed with this statement, indicating a strong trust in the individual practicing scientist in the United States.[23] (See appendix table 7-7.)

Another long-term measure of public perceptions of science comes from the General Social Survey (GSS) of the National Opinion Research Center (NORC) at the University of Chicago. The survey asks: "As far as the people running these institutions are concerned, would you say you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?" Since 1973, between 36 and 45 percent of the respondents have expressed a "great deal" of confidence in the people running science. (See figure 7-7.) The ratings for

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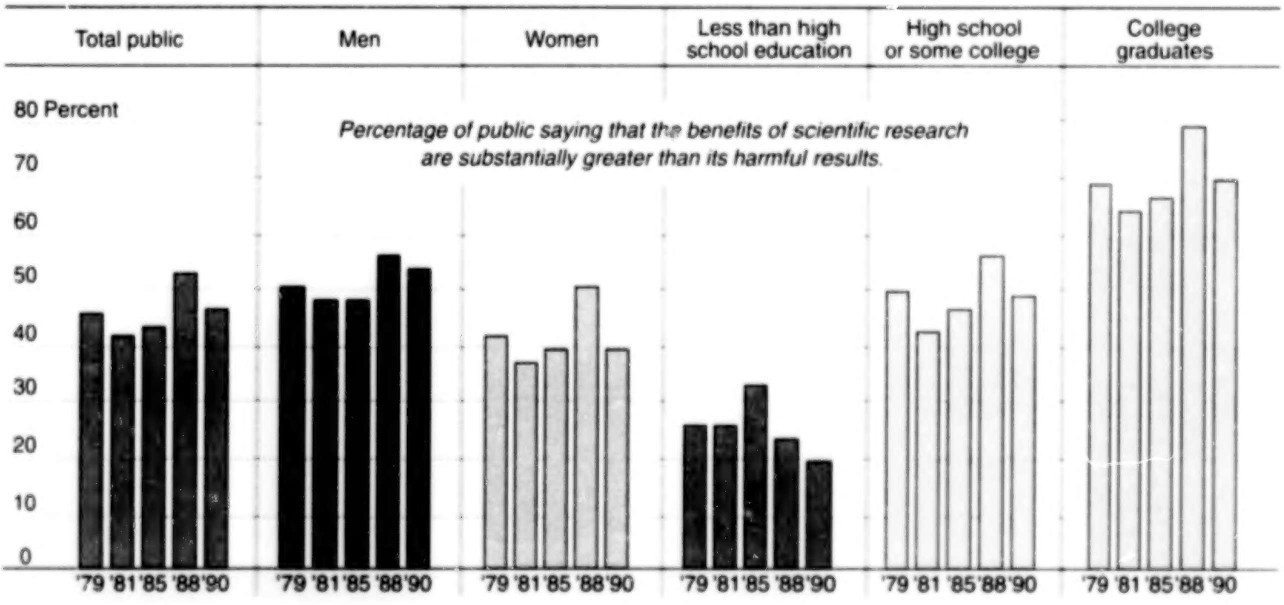
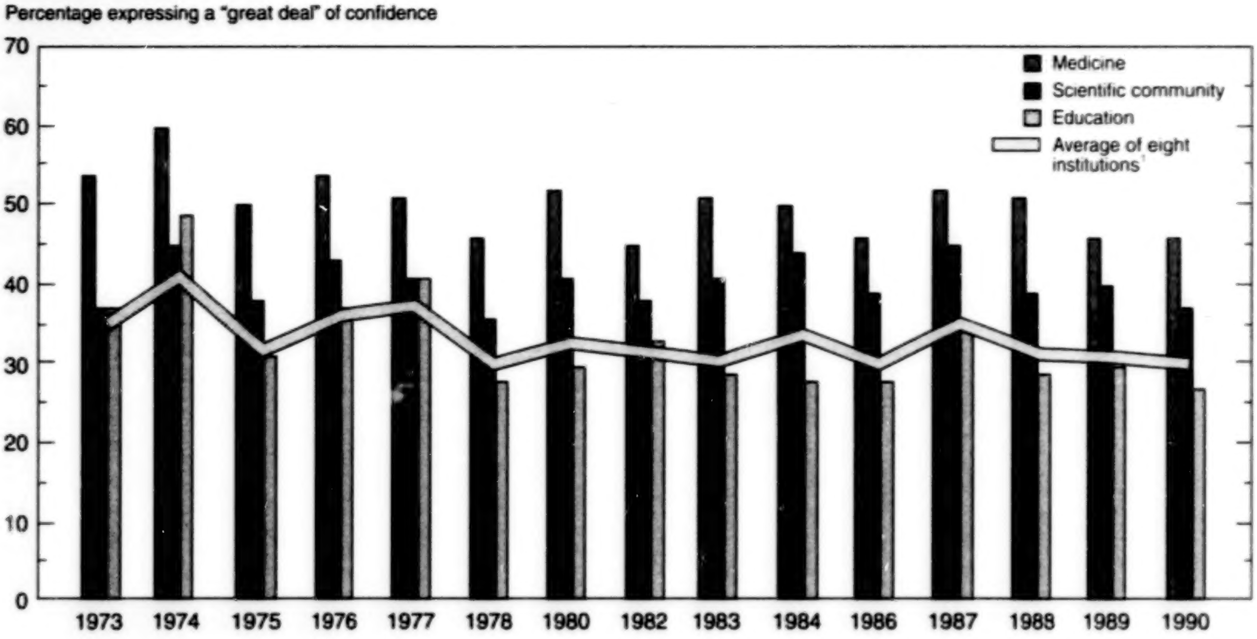
[23] Sharply contrasting results from some European countries on a similar question are presented in "Attitudes Toward S & T," pp. 184-86.

Figure 7-6.
Assessments of scientific research



See appendix table 7-8. *Science & Engineering Indicators – 1991*

Figure 7-7.
Public confidence in people running selected institutions



NOTE: Survey not conducted in 1979 or 1981, and question not asked in 1985.

[1] The eight institutions are medicine, the scientific community, U.S. Supreme Court, the military, education, major companies, organized religion, and the press.

See appendix table 7-9.

Science & Engineering Indicators – 1991

science have usually been second only to medicine, and contrast with generally downward evaluations of people running educational and political institutions, religion, and the press. (See appendix table 7-9.)

The Federal Role in Science. In 1985, 1988, and 1990, the *Indicators* survey asked respondents about their attitudes toward Federal funding of scientific research even if it has no apparent, immediate benefits. ("Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Federal Government.") About four-fifths of the adult population agreed with this statement in all three surveys, and 15 to 16 percent disagreed. (See figure O-24 in Overview.) These responses suggest a strong public support for Federal funding of basic research.[24]

Assessments of Three Technology Programs. The U.S. public is less optimistic when assessing the costs and benefits (or risks and benefits) of technological programs than of scientific research generally.

Between 1985 and 1990, assessments of the risks and benefits of genetic engineering research changed hardly at all. In both 1985 and 1990, over 45 percent of respondents stated that the benefits of genetic engineering research either substantially exceed or slightly exceed the potential risks. Relatively large proportions overall refused to answer or responded "don't know," suggesting that public attitudes toward such research and development (R&D) have not stabilized. (See appendix table 7-10.) In this question, the use of the phrase "creation of new life forms through genetic engineering research" may influence response patterns in a negative direction.[25] Men and people with college degrees are somewhat more positive about the benefits of genetic engineering research programs.

Patterns of public attitudes toward the "use of nuclear reactors to generate electricity" show greater entrenchment of attitudes on both positive and negative extremes than genetic engineering. (See figure 7-8.) Larger proportions of both the total public and people at all education levels judge the risks of nuclear power to be substantially greater than its benefits, and fewer people respond "don't know" or refuse to answer. Men are more likely to evaluate nuclear energy positively than women, and women are more likely to respond "don't know." From 1985 to 1990, some reduction in negative assessment may have occurred among college graduates,

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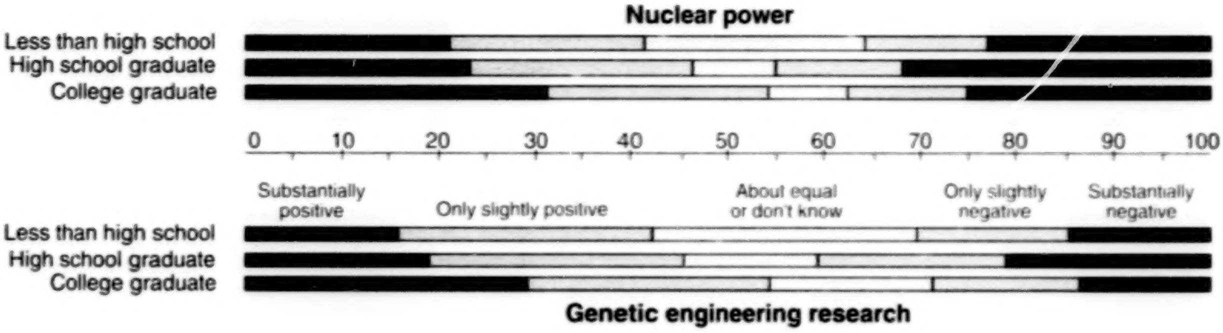
[24] For data on Federal funding of basic and other research, see chapter 4, "Federal Support for R&D," pp. 93-102.

[25] See OTA (1987) for further findings on public attitudes toward biotechnologies.

Figure 7-8.
Assessments of nuclear power and genetic engineering: 1990



See appendix tables 7-10 and 7-11 for exact question wordings.

Science & Engineering Indicators – 1991

though a quarter of these respondents still felt that the risks of nuclear power substantially exceed its benefits.

Assessments of space exploration are changing—and in a negative direction. Between 1985 and 1990, the proportion reporting "benefits exceed costs" fell from 53 percent to 42 percent, and the proportion more concerned with costs outweighing benefits grew from 38 to 47 percent. (See figure 7-9.) These changes were reported by both men and women (though men overall were more positive) and by all education levels. The proportion of college graduates perceiving substantially greater costs than benefits in space exploration grew from 17 to 24 percent. (See appendix table 7-12.)

Another dimension of declining positive attitudes toward space exploration can be seen in the changing extremes of positive versus negative assessments. Respondents were asked if they felt that the benefits [risks] *slightly* or *substantially* exceed risks [benefits]. In the case of space exploration, the extreme assessments favoring benefits *fell* by 9 percentage points, and assessments of substantially excess costs *grew* by 7 percentage points between 1985 and 1990.[26]

These changing assessments of the space program provide an opportunity to stress the different patterns of attitudes between the attentive publics and the general public. Over two-thirds of the attentive public for space exploration—a highly educated group of respondents—continued to feel in 1990 that the benefits of space exploration exceed its costs, compared with 42 percent of the general adult population. (See appendix table 7-12.) While in 1990 fewer of the attentive public for space exploration considered the benefits of the program to be "substantially" greater than its costs than was the case in 1988, relatively more considered the benefits to be "slightly" greater.

Several interpretations of this decline in positive attitudes toward the space program are possible. Miller (1991b) stresses the different patterns for this indicator for the general public and the attentive public for space exploration, stating that the attentive public is able "to place short-term advances and setbacks in a broader context." He points out that there are no active anti-space groups, as is the case with nuclear reactors, and believes that space exploration, while highly visible, has relatively low political saliency to citizens not attentive to space exploration.

Another interpretation of these changing attitudes might hold that the Challenger accident (which occurred

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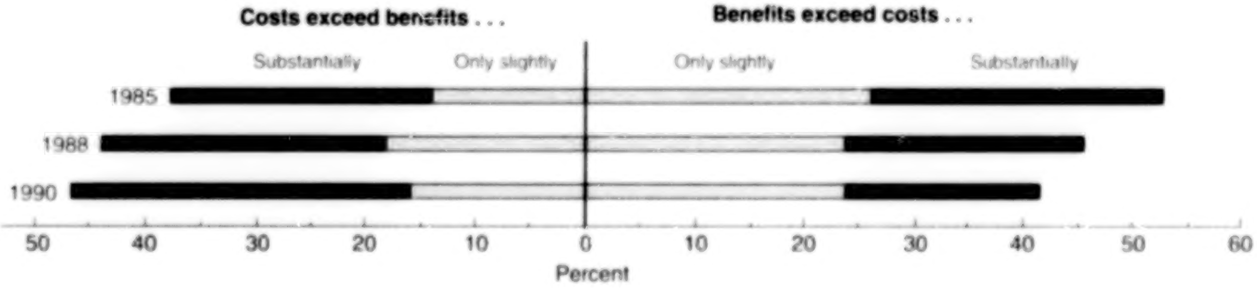
[26] Compare this with public preferences for spending on several programs; see "Spending Preferences," p. 180.

Figure 7-9.
Assessments of space exploration



NOTE: Responses for "about equal" and "don't know" are omitted.
See appendix table 7-12.

Science & Engineering Indicators – 1991

just a few months after collection of the 1985 data reported here),[27] the long-grounded and troubled shuttle fleet, the current debates about the costs of the space station, and the debate about the benefits of unmanned versus manned spaceflights, have combined to increase public consciousness of the human and financial costs of the space program and what might be achieved if the resources were put to other uses.

In any case, the changes in these indicators of public support for space exploration stand out among the indicators discussed in this chapter. Public attitudes toward S&T in the United States have been notably stable over the past decade, and changes in attitude of this magnitude and consistency toward a large, publicly funded, technological program warrant continued attention and interpretation.

Public Attitudes Toward Education

Recent increased attention in the United States to the quality and amount of education, especially education in science and mathematics, is reflected in public attitudinal data.[28] The following indicators of three themes in public attitudes toward education are presented below:

- The links people make between education and achieving other national goals;
- Public concerns about and assessments of the quality of education in the United States; and
- Public spending preferences for a number of national objectives, including education.

The Role of Education. The American public sees a clear link between education and other national goals. In 1990, a representative sample of the adult U.S. population was asked to assess the impact of an increase in the number of college-educated Americans on three general areas: solving social problems; competing in international trade; and advancing science, medicine, and technology. Seventy-five percent stated that if more Americans were to complete college, a "big improvement" would result in advancements in science, medicine, and technology. (See figure 7-10.) Fifty-five to sixty percent felt that big improvements would result in solving social problems such as crime, drugs, and homelessness, and in the U.S. ability to compete economically with the rest of the world. Respondents were more pessimistic about solving social problems than about achieving advances in international trade and in S&T.

In another national poll taken in 1989, respondents were given a list of choices in answering the question, "Which is the best policy for improving productivity in the United States?" Given the choices of investing in new plants and equipment, reducing government regulation of business, increasing R&D expenditures, and improving education and job training, 54 percent felt that improved education and job training would be the best policy (Times Mirror 1989). (See figure 7-11.) Only 10 percent felt that increasing R&D expenditures would be the best policy for improving productivity.

Concerns About Education. Since 1985, the percentage of U.S. adults who agree that the "quality of science and mathematics education in American schools is inadequate" has risen from 63 to 72 percent. (See figure O-25 in Overview.) The adult public also thinks that the quantity of science and mathematics education should be increased. Nearly 90 percent agree that "every U.S. high school student should be required to take a mathe-

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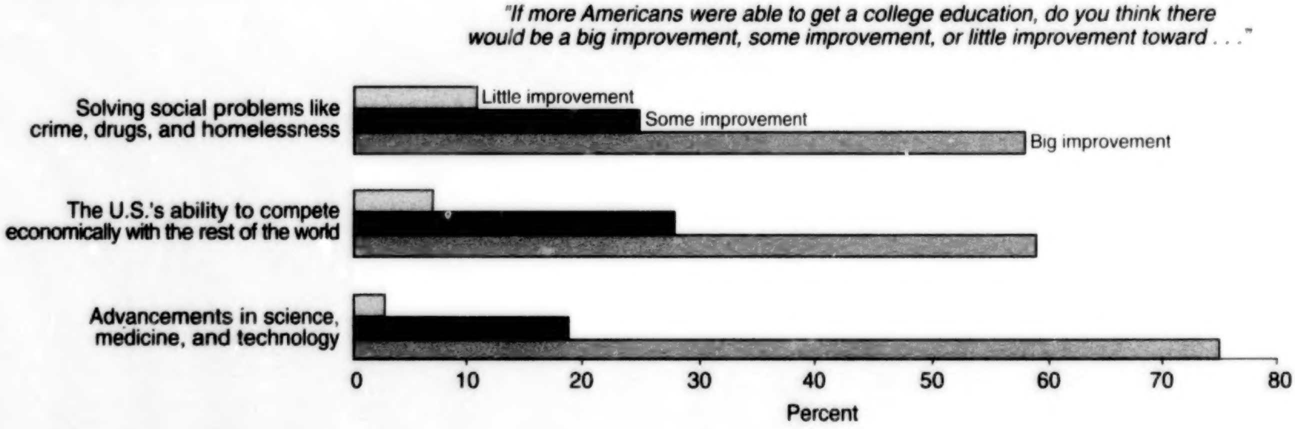
[27] See NSB (1987) for a discussion of the effects of the Challenger accident on attitudes.

[28] Measures of student performance are reported in chapter 1, "Students: Achievement, Interest, and Coursework," pp. 16-27; reform movements are covered in chapter 1, "The Policy Context," pp. 34-40.

Figure 7-10.
Benefits of college education: 1990

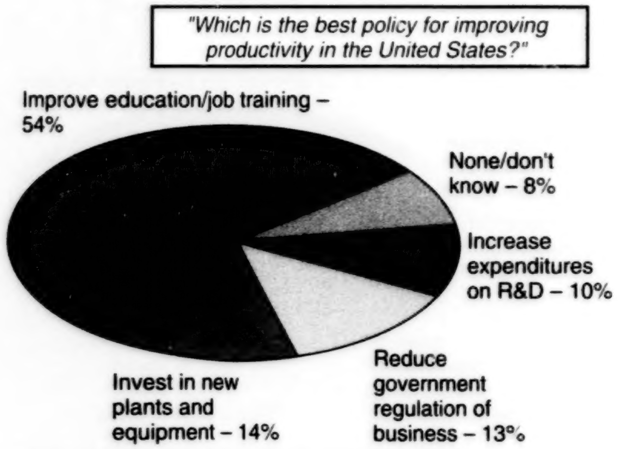


NOTE: N = 1,014.

SOURCE: Council for Advancement and Support of Education, *Attitudes About American Colleges 1990* (Washington, DC, 1990), p. 21.

Science & Engineering Indicators – 1991

Figure 7-11.
Proposals for improving U.S. productivity: 1989



NOTE: N = 2,048.

SOURCE: Times Mirror Center for the People and the Press, "The People, Press, and Politics," data diskette (Washington, DC, 1989).

Science & Engineering Indicators – 1991

matics course each year," and about 73 percent agree that high school students should take a science course every year.

The Gallup Organization and the Times Mirror Center for the People and the Press have been tracking American concern over educational and other issues. In 1988, 89 percent of the adult public stated that they were concerned about "a decline in the quality of education" in the United States, and 53 percent were "very" concerned about such a decline (Times Mirror 1989). (See text table 7-4.) Further, 75 percent were concerned about "the loss of U.S. leadership in science and technology"; overall, 33 percent were "very" concerned.

In 1989, on a similar set of questions, Americans were asked to assess whether the United States "is very strong, strong, weak, or very weak compared to other countries" in a number of areas. Fewer than half felt that the United States is either very strong or strong in "our system of public education," and half felt that the United States is weak or very weak compared to other countries in educating its citizens. (See figure 7-12.) For contrasting measures, respondents on this survey were asked to compare the United States with other countries on "technical and engineering innovation" and "scientific research." Sixty-nine percent rated the United States as strong or very strong on innovation, and 79 percent assessed U.S. scientific research as strong or very strong in comparison with other countries.[29]

Spending Preferences. Americans say they are willing to spend more for education. Since 1973, the General Social Survey has been asking people if they think "we're spending too much money, too little money, or about the right amount" on various national problems. Through 1977, about half the public felt that not enough money was being spent on education. (See figure 7-13 and figure O-25 in Overview.) By 1985, that percentage had risen to 60 percent; it then climbed sharply to over 71 percent in 1990. Percentages responding "about right" and "too much" both fell throughout the decade (NORC annual series).

Education is a problem area in which Americans have felt too little money is being invested; other such areas are "improving and protecting the Nation's health" and "improving and protecting the environment." By 1990, over 70 percent of Americans felt too little was being spent on these three problem areas. In contrast, around 10 percent thought too little was being spent on the space exploration program.[30]

Second Thoughts About S&T

Americans are not always oriented positively toward science. To probe these dimensions of U.S. attitudes toward S&T, several questions have been asked over the years to elicit respondents' attitudes when conflict occurs between science and other values. These questions are discussed in the following paragraphs, along with public confidence in new technologies.

Science and Values. In 1957, 50 percent of U.S. adults agreed that "We depend too much on science and not enough on faith." (See appendix table 7-7.) In 1990, that proportion did not change. Further, in 1990,

Text table 7-4.
Public concern about U.S. science, technology, and education: 1988

"I am going to read you a list of potential problems facing the United States. For each one, please tell me how concerned you are that it will happen."

	Degree of concern				
	Very	Somewhat	Not too	Not at all	Don't know
	Percent				
The loss of U.S. leadership in science and technology	33	42	18	3	5
A decline in the quality of education in the U.S.	53	36	8	2	2

NOTES: N = 3,021. Percentages may not total 100 because of rounding.

SOURCE: Times Mirror Center for the People and the Press, "The People, Press, and Politics," data diskette (Washington, DC, 1989).

Science & Engineering Indicators – 1991

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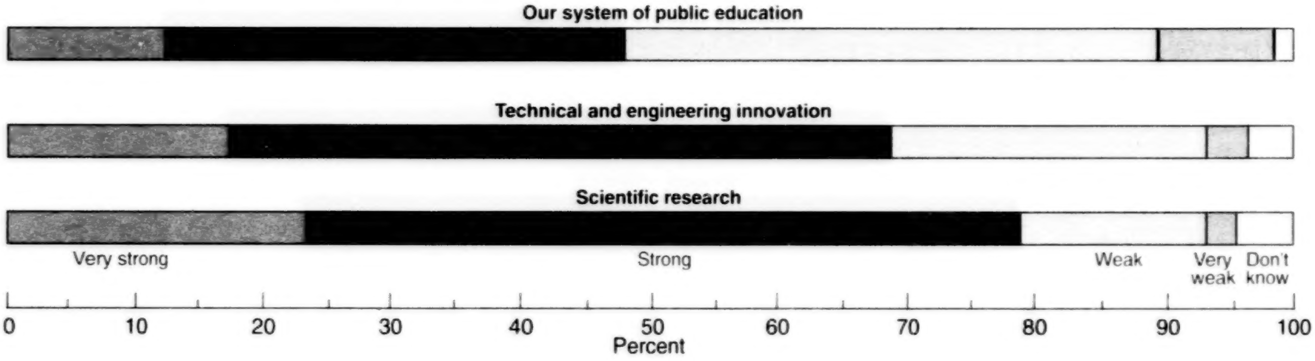
[29] However, contrast these findings with similar questions comparing specific countries; see "Perception of International Standing in S&T," pp5. 189-90.

[30] Compare these responses with the cost/benefit assessments of the U.S. space exploration program noted in "Assessments of Three Technology Programs," pp. 177-79. For an interpretation of the remarkable 1980 deviation in preferences on military spending, see footnote 20.

Figure 7-12.
U.S. strength in education, innovation, and science: 1989

"Would you say today that the United States is very strong, strong, weak, or very weak compared to other countries in the following areas?"



SOURCE: Times Mirror Center for the People and the Press, "The People, Press, and Politics," data diskette (Washington, DC, 1989).

See appendix table 7-13. *Science & Engineering Indicators – 1991*

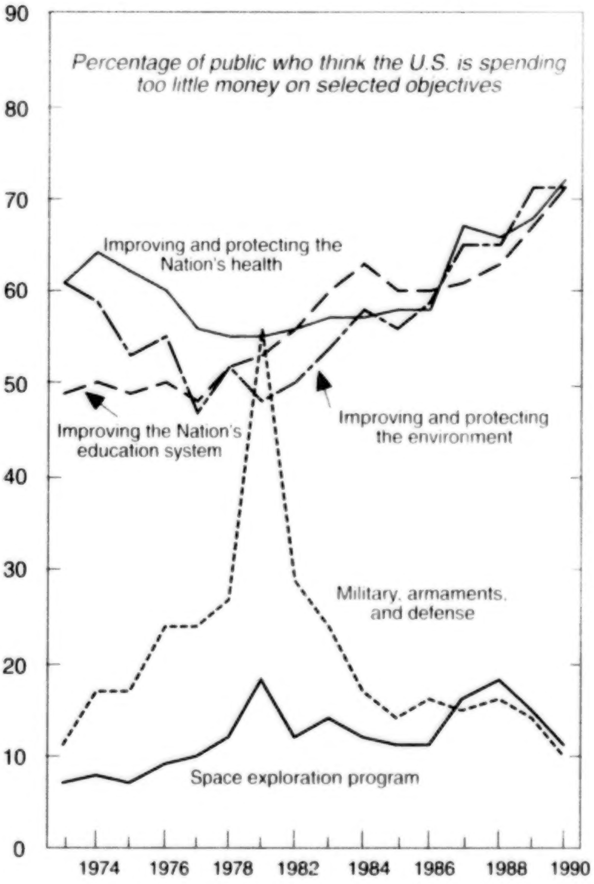
about a third of the respondents agreed with the related proposition that "One of the bad effects of science is that it breaks down people's ideas of right and wrong"; this percentage has changed little over the past decade. About 60 percent disagreed, however, that science breaks down ideas of right and wrong. Rejection of scientific explanations for natural phenomena suggests an undercurrent of fundamental adherence to religious and other explanations, even if most adults highly value science and think it has improved their daily lives.

Use of Animals in Research. Over the past 5 years, attitudes toward the use of animals in research have changed in the United States. Between 1985 and 1990, the percentage of respondents feeling that research causing pain or injury to animals is justified if such research results in new knowledge about human health has fallen, dropping from 63 percent to 50 percent.[31] (See figure 7-14.) Over the same period, the number of Americans who reject such use of animals has grown from 30 to 44 percent.

Support for anti-vivisectionist positions has grown in the U.S. population, but it has not yet reached the level found in other countries. In Britain, a 1988 survey found that only 36 percent agreed that research causing pain or injury to animals is justified if it results in new knowledge about human health (NSB 1989). In Canada in 1990, only 44 percent agreed with the same statement (Einsiedel 1990).

Expectations for New Technologies. Optimism about the development of technology "to counteract any

Figure 7-13.
Preferences for national spending



NOTE: Survey not conducted in 1979 and 1981.

SOURCE: National Opinion Research Center, *General Social Surveys Cumulative Codebook* (Chicago: University of Chicago, annual series).

See appendix table 7-14. *Science & Engineering Indicators – 1991*

harmful consequences of technological development" has declined since 1985. (See figure 7-15.) In that year, 47 percent agreed that new inventions would always be found to counteract technological damage; by 1990 that percentage had dropped to 37 percent. The proportion of respondents who disagreed with the proposition grew from 45 to 56 percent.

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[31] The *Indicators* question is designed to stress the payoffs for *human health* of such use of animals. The question is also purposefully provocative by using "dogs" and "chimpanzees"—rather than mice—in order to elicit attitudes toward use of these larger mammals.

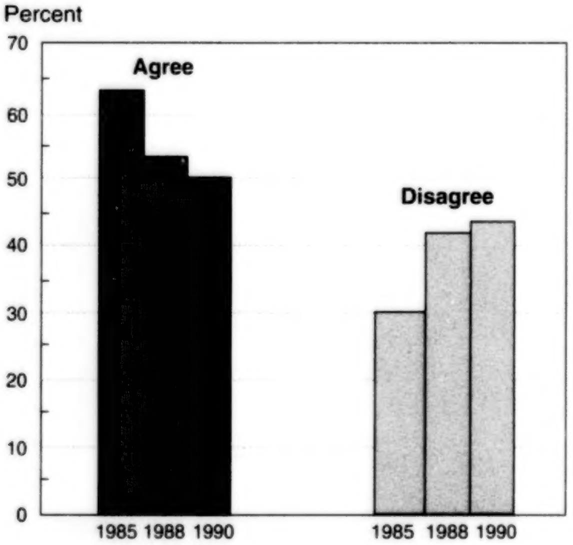
Americans have been inundated with news of disasters like the Valdez oil spill, the Challenger accident, the Chernobyl explosion, and other problems. The decreased optimism about the availability of technological fixes for these problems may reflect growing doubt about the tractability of much of this damage.

International Comparisons of Attitudes Toward S&T

As countries have increasingly measured and assessed their national efforts in S&T over the past decade, they have also demonstrated a growing interest in national public attitudes toward S&T—and the comparability of these attitudes.[32] Occasional, internationally comparative survey work has been reported in *Indicators* from as early as 1980. By the end of the decade, the governments of Great Britain, France, and Japan were all sponsoring national attitudes surveys, usually with some coordination on questions and themes with the U.S. *Indicators* series. National surveys of the adult publics in Canada in 1989 and Japan in 1990 featured extensive coordination with U.S. researchers, thus adding valuable data to this growing body of comparative research (Einsiedel 1990 and Office of the Prime Minister of Japan 1991).

Figure 7-14.
Research with animals

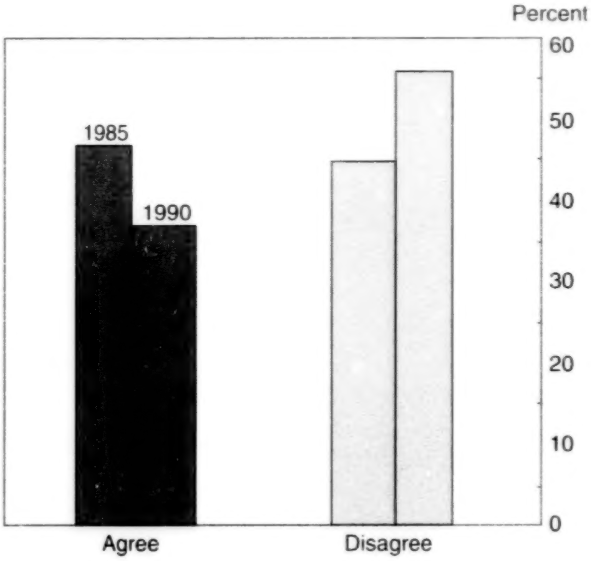
"Scientists should be allowed to do research that causes pain and injury to animals like dogs and chimpanzees if it produces new information about human health problems."



See appendix table 7-7. *Science & Engineering Indicators – 1991*

Figure 7-15.
Trust in technology

"New inventions will always be found to counteract any harmful consequences of technological development."



See appendix table 7-7. *Science & Engineering Indicators – 1991*

In 1989, the European Community (EC), through the Eurobarometer program of the Commission of the European Communities, sponsored an EC-wide survey of public attitudes toward and knowledge of S&T (CEC 1989).[33] In one stroke, the number of countries with comparable data on some of the traditional *Indicators* measures increased from 4 to 15. (See "Availability of Data," p. 183.) The following comparisons are based on the EC survey of 12 nations of Europe (1989) and surveys in Japan (1990), Canada (1989), and the United States (1990).[34]

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[32] The recent growth in the number of researchers conducting surveys of attitudes toward S&T, and of governments and other bodies sponsoring such surveys, led to the formation in 1990 of the International Council for the Study of Public Attitudes Toward S&T. The Council meets once a year to coordinate survey plans and discuss technical and other questions involving comparability of the data. The Council's next meeting will be in 1992 in Tsukuba, Japan.

[33] NSB (1989) reported some early data from this EC survey, but none at the national level.

[34] Comparing survey results from this many countries is not unproblematic, despite the coordinative efforts made and the attention given to technical comparability of survey operations. The indicators discussed in this section should be interpreted cautiously both because of the normal measurement errors encountered in any public survey as well as the following considerations:

Availability of Data

The following paragraphs provide information for potential users of the large data sets discussed in this chapter.

Canada: The telephone survey of 2,000 Canadians was performed by Decima Research of Toronto under the direction of Edna Einsiedel, University of Calgary, in November and December 1989. The survey performers telephoned adult Canadians at random, stratified according to the population in each province.

Data diskettes containing the Canadian survey results can be obtained from Professor Einsiedel, Graduate Program in Communication Studies, University of Calgary. Other details on survey methodology and results as well as the questionnaire are in Einsiedel (1990); further analyses of the data are presented in Einsiedel (1991).

European Community: The 12-nation survey for the Eurobarometer program of the EC was coordinated by Faits et Opinions in Paris and conducted by affiliated survey groups in each country in March 1989 (CEC 1989). The data are stored at the Belgian Archives for the Social Sciences (1 Place Montesquieu, B-1348 Louvain-La-Neuve). The in-person interviews were conducted with adults 15 years of age or older using a variety of sampling methodologies in the different countries. See also Bauer, Durant, and Evans (1991) and Durant et al. (1991) for analyses using these data.

This chapter reports data from the EC-sponsored survey for the 12 member countries and for the Community as a whole (reported as "Europe"). Country-level data are weighted to the population profile of the individual country, and data for Europe are separately weighted to the total of the Community member nations.

Japan: The Japanese survey was conducted in January 1990 by Shin Joho Center of Tokyo for the Office of the Prime Minister of Japan. Using a two-stage stratified probability sample, the survey performers conducted in-person interviews with 2,239 adults 18 years or older.

Further details on survey methodology and extensive data tables are presented in Office of the Prime Minister (1991). As of this writing the data diskettes have not been made available.

United States: Tabulations from the 1979, 1981, 1983, 1985, 1988, and 1990 surveys are reported in Miller (1991a), and the data diskettes with complete documentation for these surveys are available from the International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 2001 N. Clark Street, Chicago, IL, 60614 (telephone: 312-549-0607). A codebook incorporating the results from 1979 through 1990 is also available at a nominal charge from the center.

The 1985 survey data set includes two additional interview cycles, one each following the Challenger and Chernobyl accidents. Data from before 1979 are reported in NSB (1973, 1975, and 1977).

See Miller (1987) and Miller, Prewitt, and Pearson (1980) for discussions of question design and survey methodology; see Miller (1991b) for further analyses.

Because of technical and other uncertainties in the indicators that follow, this section adopts a somewhat more cautious tone than the preceding section. Broad patterns are emphasized rather than absolute differences on indicators, except where these differences are notably large or intriguing. The discussion reports measures for total national populations only and does not provide cross-cuts for otherwise interesting subpopulations.

Despite these caveats, the following indicators of public attitudes toward S&T add an important new dimension to understanding the different postures of national populations toward S&T. Even these broadstroke comparisons reveal striking differences—and important similarities—among Japan and the countries of North America and Western Europe.

This section opens with comparisons of national response rates on a set of questions designed to indicate general public attitudes toward S&T. Country-level responses are then compared on the degree of interest in, and knowledge about, issues concerning S&T. Next, in a discussion of the distribution of scientific knowledge among the adult populations of these countries, two indicators of knowledge about science are introduced. One deals with the extent to which the public describes astrology as "scientific"; the other is a set of simple true/false questions on elementary knowledge of S&T.

The section concludes with a comparison of how the adults of these different countries assess the relative standings of the United States, Europe, and Japan in scientific achievement and in technological innovation. The

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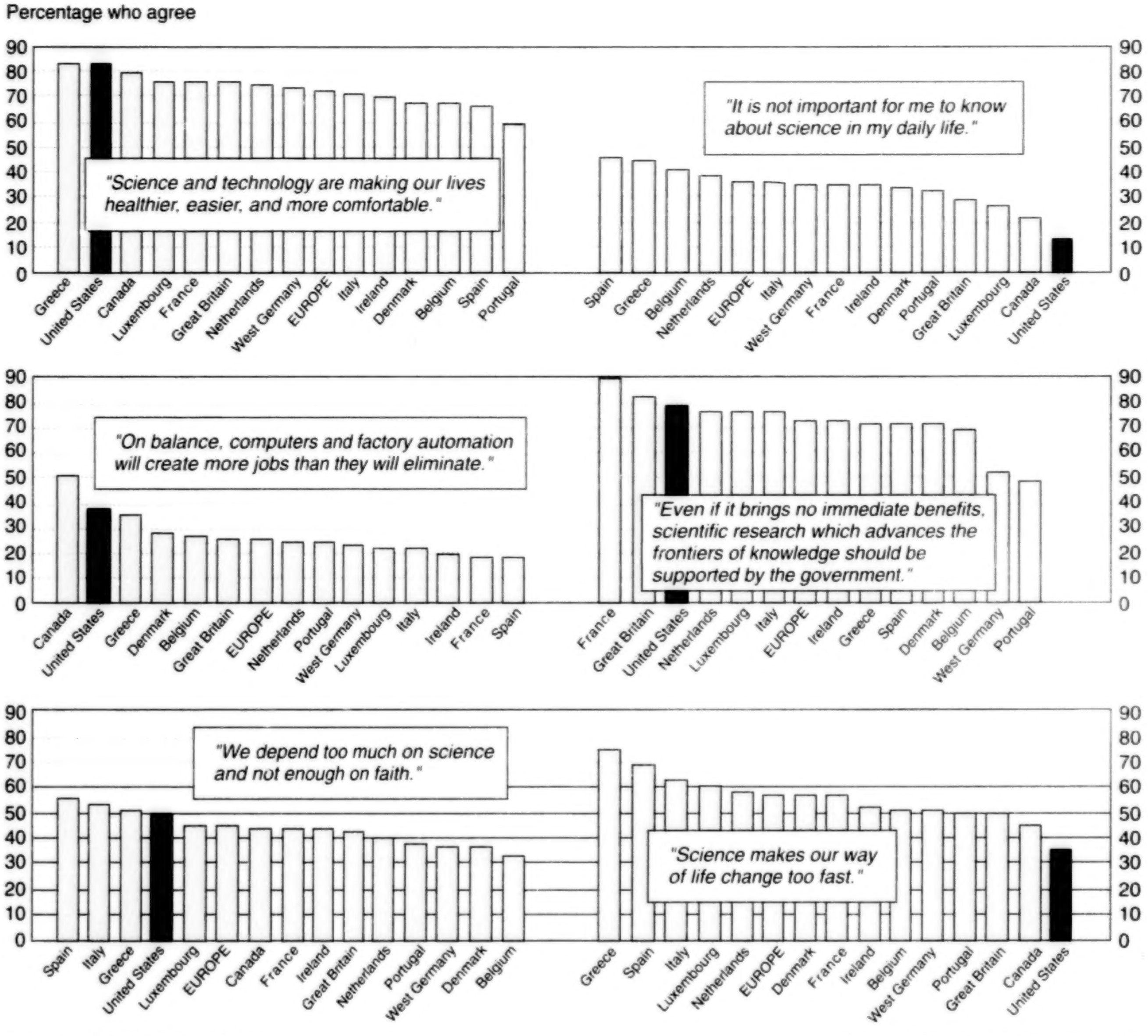
- *Language*—even basic terms like "science" and "technology" may have different cultural connotations and thus lead to apparent, but not necessarily real, differences in survey results.
- *Public polling practices*—differences among countries in the state of the art of their polling practices may influence the technical quality and comparability of the data.
- *Propensity to participate in polls*—different national propensities to participate in public polls, or to respond openly and honestly when polled, may affect the survey results.
- *Survey instruments*—measurement differences surely resulted from the use of different national survey instruments. Differences in question order and questionnaire content can affect survey results, but the extent of this effect is unknown.
- *Survey timing*—for comparison purposes, the surveys ideally should have been conducted simultaneously. The effect of the difference in timing is unknown.

Figure 7-16.
International comparisons of public attitudes toward science and technology



See appendix tables 7-7 and 7-15.

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widely diverging response patterns show the different ways national populations view their country's relative position in research and technological development; these patterns complement several of the indicators reported in chapter 6.

Attitudes Toward S&T

The United States, Canada, and Europe. Six common questions are available to compare the attitudes toward S&T of adults in 12 European countries and the United States. Canadian measures are available for five of these.[35] (See figure 7-16.)

Respondents in the United States and Canada gave similar responses to several questions. For instance, a majority of adults in both countries agreed that "Science and technology are making our lives healthier, easier, and more comfortable,"[36] and most often disagreed that "It is not important for me to know about science in my daily life." Respondents in these two countries also most often disagreed that "Science makes our way of life change too fast."

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[35] The survey questionnaire of the European Community gave respondents a choice of "neither agree nor disagree"; the Canadian and U.S. questionnaires did not. The effect of this difference in response choices is not known. Only the totaled responses for "agree" and "agree strongly" are reported here.

The response patterns of the United States and Canada on these and other items suggest that the populations of the two countries are largely similar in their general attitudes toward S&T. They agreed in similar proportions—and were more optimistic compared to the European nations—that "On balance, computers and factory automation will create more jobs than they will eliminate."

However, a higher percentage of the U.S. respondents than of the Canadian felt that "We depend too much on science and not enough on faith." The United States has traditionally registered relatively large percentages that agree with this proposition. Comparing the U.S. response on this item to that of other countries shows that the United States ranks just below Spain, Italy, and Greece and just above Luxembourg in its agreement. These four European countries all register above the EC's average agreement with this statement. (See appendix table 7-7 for the U.S. time trend on this question.)

Another question measured approval by the adult population of *governmental* support of scientific research "even if it brings no immediate benefits."[37] The U.S. respondents were generally in high agreement with this proposition, but France and Great Britain registered even higher levels of agreement. The French, in fact, approached unanimity (over 90-percent agreement) for a strong governmental role in the support of basic research. In very sharp contrast were the response rates of West Germany: barely a majority agreed with the statement. These very different response patterns of two large and scientifically influential European countries are not easy to explain.[38]

The Netherlands also had anomalous response patterns on several of these questions (Second Chamber 1990). Although registering rather high approval of governmental funding of research, well over a majority of the adults in Holland agreed that science makes life change too fast. Moreover, nearly half of the Dutch adults *disagreed* that the benefits of science are greater than any harmful effects, with a full 26 percent "strongly" disagreeing.[39]

The Netherlands public also seemed unwilling to leave decisions to scientists; well over half disagreed with the statement that "Scientists can be trusted to make the right decisions."[40] Majorities in Denmark and Great Britain also disagreed with this statement. Responses to this question varied considerably across Europe, suggesting fundamentally different degrees of trust in scientists' decisionmaking.

The United States and Japan. The 1990 U.S. and Japanese surveys each gauged agreement with the proposition that "Science and technology are making our lives healthier, easier, and more comfortable." Figure 7-17 compares the national totals of the two countries on this indicator. While similar percentages *strongly* agreed with the proposition, Japanese adults were far more likely to disagree, to disagree strongly, or to answer "don't

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[36] See below for a comparison of the United States and Japan on this question.

[37] The U.S. question asked about support by the *Federal* Government, while the European questions referred only to "government." The Canadian survey did not include this question.

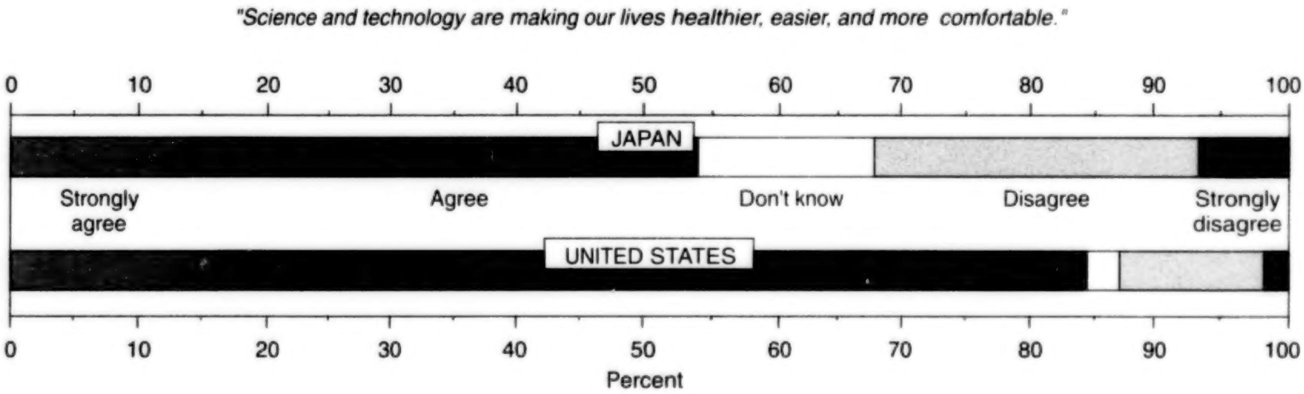
[38] See R&D expenditure patterns for these countries in chapter 4, "International Comparisons," pp. 107-10.

[39] This question and others not asked in the U.S. survey are reported in appendix table 7-15.

Similar results from an earlier survey were reported for The Netherlands. In response to the question "In the long run, do you think the scientific advances we're making will help or harm mankind?," 36 percent responded "will harm," 22 percent "will help," and 34 percent "both" (NSB 1987, pp. 18 and 332).

[40] For a related question in the 1990 U.S. survey, 80 percent of U.S. adults agreed that "Most scientists want to work on things that will make life better for the average person." See appendix table 7-7.

Figure 7-17.
Japanese and U.S. assessments of science and technology



See appendix tables 7-7 and 7-16.

know." Overall, about 85 percent of the U.S. respondents acknowledged the beneficial effects of S&T on their daily lives compared to about 55 percent of the Japanese. Fewer than half of the Japanese respondents agreed, in answer to a question not raised in the U.S. survey, that S&T has had a positive impact in Japan on working conditions. (See appendix table 7-16.)

On two other questions not asked of the U.S. respondents, however, the Japanese displayed attitudes toward S&T that were both more positive and more mixed. When asked whether S&T has "improved, worsened, or not changed" the standard of living, three-fourths agreed that the standard of living has been improved. A related question asked: "Science and technology have both positive and negative effects. Which do you think has been greater—the positive effects or the negative effects?" Fifty-three percent of the Japanese responded that positive effects have been greater, 31 percent responded "about the same," and 7 percent favored the negative assessment.

About 38 percent of the Japanese respondents felt that S&T has "worsened" morality. Thirty-five percent felt there was no change, and about one-fifth declined to answer the question. On a related question asked in the United States, about one-third of adults agreed that "One of the bad effects of science is that it breaks down people's ideas of right and wrong." (See appendix table 7-7.)

In sum, on these sets of comparisons, U.S. and Japanese responses were not dissimilar. In the United States, somewhat larger majorities overall expressed positive attitudes toward S&T and its impact on daily life, but on several questions with different wordings the Japanese were also strongly positive. About a third of the adults in each country indicated a concern with the effects of science on moral issues.

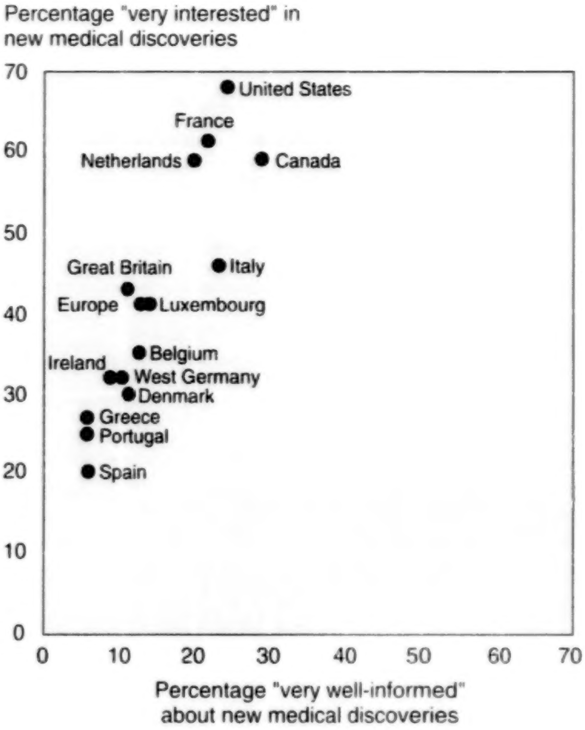
Attention to Issues in S&T

The adult publics of the countries of Western Europe and of Canada and the United States appear to have different patterns of interest in and knowledge about issues involving S&T.[41]

For all the countries surveyed, by far the greatest degree of interest was in new medical discoveries. Four countries dominated in this degree of interest: the United States, France, Canada, and The Netherlands. (See figure 7-18.) Adults in these countries (and in Italy) also ranked high on the percentages very interested in science and new inventions and technology. Of all the countries, French respondents claimed most often to be very interested in scientific discoveries and in inventions and technology.

The adult populations of the United States and Canada reported similar rates of being "very interested" in new scientific discoveries, new inventions and technologies, and new medical discoveries. Their rates were generally higher than in Western Europe. (See appendix table 7-17.) U.S. and Canadian respondents also reported similar degrees of feeling "very well-informed" about these sets of issues. The similar responses of Canadian and U.S. adults on these questions indicate the close cultural ties between the two countries.

Figure 7-18.
Interest in and knowledge about new medical discoveries



See appendix tables 7-1, 7-2, and 7-17.

Science & Engineering Indicators – 1991

Respondents in Greece, Spain, and Portugal consistently reported lower rates of being "very interested" in or "very well-informed" about any of the three sets of issues. (The adult publics in these three countries also ranked lowest on knowledge of basic scientific ideas; see "Knowledge of Scientific Conclusions," pp. 187-89.)

Two interesting results among the European nations were the low self-reports of interest and knowledge by adults in Denmark and West Germany for all three of the areas. The Danes have traditionally scored high on international tests of science and mathematics ability, and they outranked adults in all other nations on the knowledge questions discussed below (see pp. 187-89). In West Germany adults reported being very interested and very well-informed at rates 50 percent or lower than in other European countries. Reasons for these differences are not immediately clear. Both of these countries have significant R&D budgets and both have high levels of education.

Is Astrology Scientific?

To ascertain the public's degree of belief in pseudoscience, the U.S. *Indicators* series has tracked the extent

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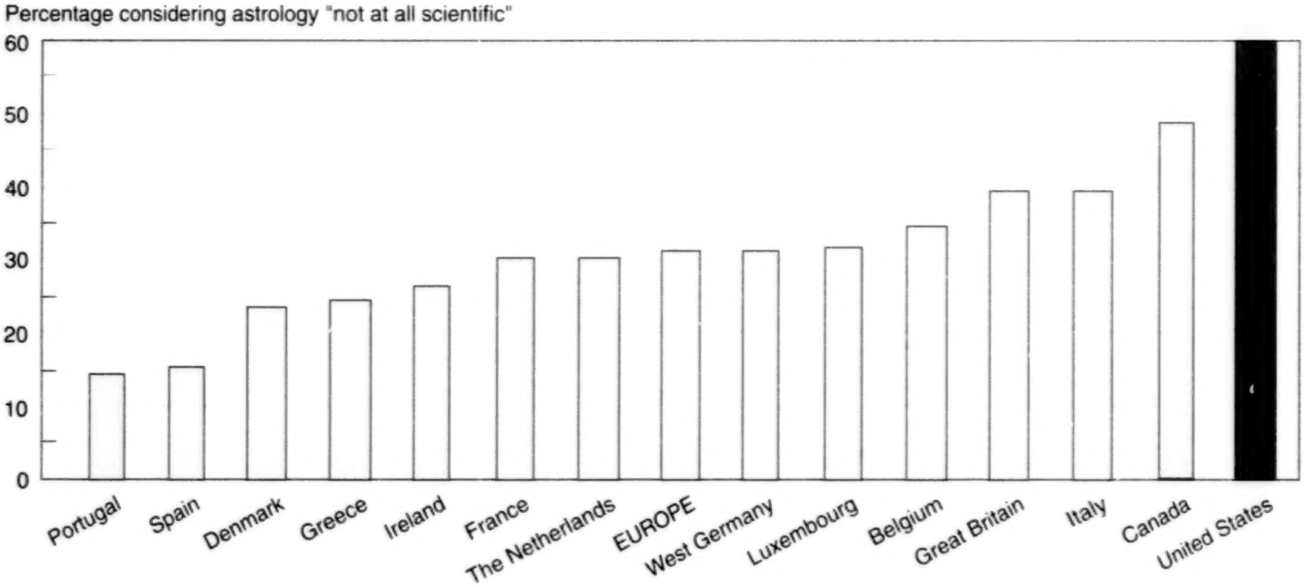
[41] No measure of attentiveness is developed here for Canada, Europe, or Japan. However, see Einsiedel (1990) on Canadian attentiveness and Durant et al. (1991) on European.

Figure 7-19.
Perceptions of astrology



See appendix table 7-18.

Science & Engineering Indicators – 1991

to which respondents feel that astrology is scientific. Astrology and science might appear, to the uninitiated, to use similar arcana: jargon, symbols, and astronomical bodies as reference points.

Rejection or acceptance of astrology as a science may be considered an indicator of the understanding of the scientific method and of the nature of scientific knowledge. Rejection of astrology as scientific may be interpreted as an indicator of scientific understanding.[12]

Majorities of respondents in several European countries accepted astrology as either "very" or "sort of" scientific, whereas about 60 percent of U.S. respondents rejected astrology as "not at all scientific." (See figure 7-19 and appendix table 7-18.) In no country in Europe did more than 40 percent of the respondents state that astrology is not scientific. Education level seems surprisingly unrelated to rejection of astrology. In Denmark, for example, some 60 percent of the adult population thought astrology is very or sort of scientific; similar findings were reported for other countries with high education levels.

"Don't know" responses were high for this question in most European countries (but not in France, Great Britain, and Luxembourg). In several countries, 20 to 25 percent claimed not to know the answer to the question.

Knowledge of Scientific Conclusions

The Canadian, European, Japanese, and U.S. surveys each contained several questions designed to measure knowledge of various basic scientific concepts and facts. These questions can be used to compare (1) total national average accurate responses and (2) distributions within the national populations of accurate responses.

The United States and Canada. On 11 questions available to compare scientific knowledge of the Canadian and U.S. populations, the mean number of correct responses was slightly higher in Canada—7.3 versus 7.0 in the United States. (See appendix table 7-19.) The two countries exhibited very similar response patterns on all but one question: the theory of evolution. U.S. respondents answered this question correctly only 45 percent of the time, versus 58 percent in Canada. The distributions of correct responses on these 11 questions were strikingly similar for the two populations. (See figure 7-20.)

The United States and Europe.[13] Ten questions were available to compare the 12 members of the

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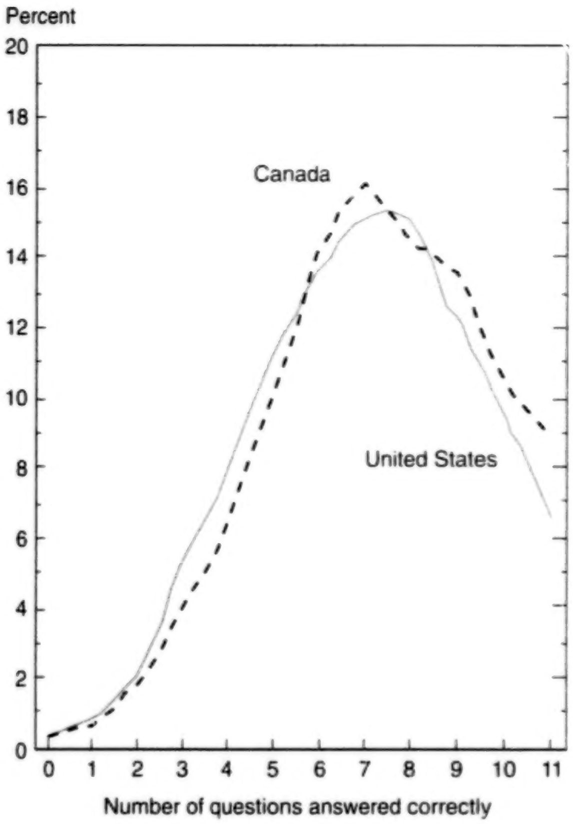
[12] Interpretation of this indicator is problematic. For example, in the United States, relatively large percentages of otherwise educated respondents report that they sometimes read their horoscopes. Far fewer, however, report that they base their actions on what their horoscopes say (NSB 1989).

In an analysis of French data not shown here, Boy (1991) points out that in France belief in different practices of the parasciences differs according to education level. For example, relatively more French adults with higher educational levels believe in telepathy. In contrast, belief in astrology is inversely related to education level. Boy (p. 5) goes on to note: "An analysis of the correlations shows that, as a rule, irrational beliefs scarcely affect support for science."

[13] This discussion borrows heavily from Bauer, Durant, and Evans (1991). In their analysis of only the European data, and using a slightly expanded question set, the authors discuss relationships among attitudes, knowledge, and other socioeconomic variables.

Figure 7-20.
U.S. and Canadian knowledge of science and technology



See appendix table 7-19 for questions.

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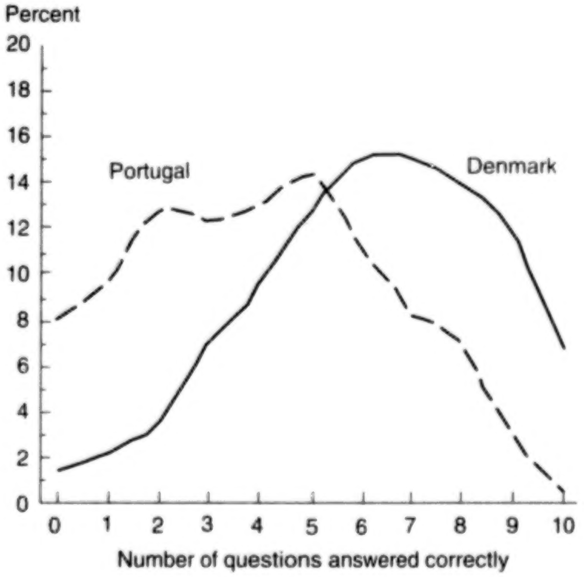
European Community with the United States on a scale of scientific knowledge. (See appendix table 7-20.) The average (mean) national rankings of these countries on these 10 questions are shown in figure 7-21. Denmark ranked highest and Portugal lowest, with a general tendency of increasing rank on this measure from south to north among European countries.

The United States's mean accurate response rate was virtually the same as that for the European Community overall. Response rates on individual questions were also similar for the United States and the EC, except for rather lower knowledge in the United States of planetary motion and higher knowledge of continental drift.

Patterns of scientific knowledge distribution are also of interest. Figure O-26 in the Overview shows that correct responses to these 10 questions were nearly identically—and fairly normally—distributed in the U.S. and EC populations. Within Europe, however, these distributions varied widely, with particularly uneven distributions in both countries with high levels of knowledge (e.g., Denmark and Britain) and those with low levels (Spain, Greece, and Portugal).[11] (See figure 7-21.)

Figure 7-21.
Distributions of scientific knowledge

	Mean number of 10 questions answered correctly	N
Denmark	6.23	1,013
Great Britain	6.17	976
Luxembourg	6.17	303
France	6.11	1,004
Netherlands	6.05	1,025
West Germany	5.97	1,024
United States	5.79	2,033
EUROPE	5.75	11,677
Italy	5.66	1,022
Northern Ireland	5.27	300
Belgium	5.24	1,000
Ireland	5.19	1,006
Spain	5.03	1,001
Greece	4.71	1,000
Portugal	4.09	1,000



See appendix table 7-20. *Science & Engineering Indicators – 1991*

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[11] Bauer, Durant, and Evans (1991) note that the Chronbach Alphas of Spain and Portugal are unusually high compared to the countries' knowledge measures. (Alphas are measures of consistency in individual responses; they show the extent to which persons responding correctly to one item also tended to respond correctly to other items. The alphas shown in appendix table 7-20 are all moderate to moderately high.)

To explain this relationship, they propose (p. 7) that the tendency for respondents to give consistent answers may increase in countries with sharp contrasts in educational attainment and that "in lower [knowledge] level countries the social structure seems to be more important for the distribution of science than in higher level countries." Figure 7-21 shows a strong bimodal distribution in Portugal compared with Denmark. Such a distribution shows that some people have little scientific knowledge, while others have much more. A country with such a distribution may have a more elitist science education system.

Text table 7-5.
U.S. and Japanese knowledge of science and technology

	Correct		Don't know[1]	
	United States	Japan	United States	Japan
	Percent			
1. "The center of the earth is very hot."	79	78	14	18
2. "Lasers work by focusing sound waves."	37	14	37	45
3. "Electrons are smaller than atoms."	41	37	35	48
4. "Antibiotics kill viruses as well as bacteria."	30	8	11	21
5. "The universe began with a huge explosion."	32	54	35	34
6. "The continents on which we live have been moving their location for millions of years and will continue to move in the future."	77	82	15	15
7. "Human beings, as we know them today, developed from earlier species of animals."[2]	45	79	14	11

NOTE: Incorrect responses were omitted.

[1] Response categories in the U.S. surveys were "true," "false," or "don't know." In the Japanese survey, respondents were offered choices of "strongly agree," "agree," "disagree," "strongly disagree," or "don't know."

[2] Japanese wording: "What do you think about the following statement? Human beings developed from earlier species of animals."

SOURCES: Office of the Prime Minister of Japan, Public Relations Office, *Opinion Survey on Science, Technology, and Society*, T. Welch, trans. (Washington, DC: Science Resources Studies Division, National Science Foundation, 1991); and J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

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The United States and Japan. Seven common questions concerning simple S&T concepts were asked on the 1990 U.S. and Japanese surveys. (See text table 7-5.) The responses of these culturally very different populations displayed both strong similarities and striking differences:

- On questions dealing with purely scientific conclusions, and on those that did not concern subjects on which U.S. respondents have traditionally held strong moral beliefs, the U.S. and Japanese response patterns were very similar.
- On two questions dealing with lasers and antibiotics, the Japanese correct responses were much lower than American.
- On two questions involving topics about which Americans feel strongly—evolution and the origin of the universe—U.S. respondents answered incorrectly more often than the Japanese by 20 to 30 percentage points.

Perception of International Standing in S&T

The U.S., Japanese, and Western European populations have different conceptions of their countries' relative international ranking in S&T capabilities.[45] The following paragraphs describe these different assessments, first in terms of basic scientific capabilities, then in terms of military capabilities.

Basic Scientific Achievements. U.S. respondents were confident that the United States is ahead of Europe and the Soviet Union in basic scientific achievements. (See text table 7-6.) The percentages of adults placing the United States ahead of Europe and the Soviet Union in basic scientific achievements increased directly with educational level. The attentive publics for S&T-related issues were also generally more positive in their assessments of U.S. standing in basic science. (See appendix table 7-21.)

In sharp contrast, 50 percent of Americans believed that the United States is behind Japan in basic scientific achievements. This proportion is up considerably from the 29 percent of Americans who held this belief in 1985 (NSB 1987). Higher percentages of women and younger adults cited Japanese superiority in basic science. (See appendix table 7-21.)

These results are surprising since Japan has, until recently, been engaged in relatively little basic research. It is possible that U.S. respondents confused "science" with "technology" in their answers. Two attentive publics—one for scientific discoveries and one for space exploration—both placed the United States behind Japan in basic science less often. As noted earlier, these publics were among the most highly educated of the attentive groups discussed in this chapter. (See text table 7-1.)

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[45] Questions on this topic were not asked in the Canadian survey.

Text table 7-6.
U.S. assessments of basic science and military technology

	Versus Europe	Versus the Soviet Union	Versus Japan
		Percent	
Basic science			
U.S. is ahead	46	61	23
U.S. is at same level	36	28	25
U.S. is behind	14	7	50
Military technology			
U.S. is ahead	69	46	71
U.S. is at same level	26	42	18
U.S. is behind	3	9	7

NOTE: "Don't know" responses were omitted.

See appendix tables 7-21 and 7-23.

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The 46 percent of Americans who felt that the United States is ahead of Europe in basic science is matched by 46 percent of Europeans who agreed with them. However, within the member countries of the EC, strong differences are evident on this indicator. (See appendix table 7-22.) Large majorities in Italy, Spain, Ireland, and Greece place Europe behind the United States; populations in the other countries viewed Europe more favorably in the comparisons. In these assessments, it is possible that the respondents were making reference to *national* rather than *European* standing.[16] On the other hand, each national group may view "Europe" from a unique national perspective.

Europeans were less pessimistic about their standing in basic science vis-à-vis the Japanese than were Americans. In Europe, 41 percent felt that Europe is *less* advanced than Japan. West Germans stood out among the European respondents: only 22 percent felt that Europe is less advanced than Japan in basic science, another 30 percent felt the two countries were at the same level, and 39 percent felt that Europe is more advanced than Japan in basic science. (See appendix table 7-22.)

The Japanese, when asked a similar question in 1987, tended to disagree with the U.S. responses and agree with the European responses (NSB 1987).[17] Only 20 percent felt that Japan was ahead of the United States in "basic science and technology," but strong majorities placed Japan ahead of West Germany, Britain, and France in these achievements.

Military Technologies. Pronounced changes have occurred in Americans' assessments of the military technology of the United States and the Soviet Union. In 1985, 33 percent of U.S. respondents felt that the United States was ahead of the Soviet Union in military technology; 40 percent felt it was at the same level (NSB 1987). In 1990, those percentages had changed to 46 percent and 42 percent, respectively. (See text table 7-6.) Also in 1990, even higher percentages of highly educated respondents and of the attentive publics for nuclear power, new technologies, and space exploration placed the United States ahead of the Soviet Union in military technologies. (See appendix table 7-23.)

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[16] Bauer, Durant, and Evans (1991, p. 9) make the same observation.

[17] The Japanese were asked about West Germany, Great Britain, and France, not about "Europe."

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Appendix A
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Appendix table 1-1.

Student achievement scores in science, by age, gender, and race/ethnicity: 1970-90 assessments

Gender and race/ethnicity	1970	1973	1977	1982	1986	1990
9-year-olds						
Total	224.9	220.3	219.9	220.9	224.3	228.7
Male	227.6	222.5	222.1	221.0	227.3	230.3
Female	222.7	218.4	217.7	220.7	221.3	227.1
White	235.9	231.1	229.6	229.1	231.9	237.5
Black	178.7	176.5	174.9	187.1	196.2	196.4
Hispanic	NA	NA	191.9	189.0	199.4	206.2
13-year-olds						
Total	254.9	249.5	247.4	250.2	251.4	255.2
Male	256.8	251.7	251.1	255.7	256.1	258.5
Female	253.0	247.1	243.8	245.0	246.9	251.8
White	263.4	258.6	256.1	257.3	259.2	264.1
Black	214.9	205.3	208.1	217.2	221.6	225.7
Hispanic	NA	NA	213.4	225.5	226.1	231.6
17-year-olds						
Total	304.8	295.8	289.6	283.3	288.5	290.4
Male	313.8	304.3	297.1	291.9	294.9	295.6
Female	296.7	288.3	282.3	275.2	282.3	285.4
White	311.8	303.9	297.7	293.2	297.5	300.9
Black	257.8	250.4	240.3	234.8	252.8	253.0
Hispanic	NA	NA	262.3	248.7	259.3	261.5

NA = not available

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

See figures 1-1, 1-2, and 1-3, and figure O-12 in Overview. *Science & Engineering Indicators – 1991*

Appendix table 1-2.

Percentage of students achieving at or above science proficiency levels, by age: 1977-90 assessments

Level and description	Age	Assessment years			
		1977	1982	1986	1990
		Percent			
150 – Knows everyday science facts. Students at this level know some general scientific facts of the type that could be learned from everyday experiences. They can read simple graphs, match the distinguishing characteristics of animals, and predict the operation of familiar apparatus that work according to mechanical principles.	9	94	95	96	97
	13	99	100	100	100
	17	100	100	100	100
200 – Understands simple scientific principles. Students at this level are developing some understanding of simple scientific principles, particularly in the life sciences. For example, they exhibit some rudimentary knowledge of the structure and function of plants and animals.	9	68	71	72	76
	13	86	90	92	92
	17	97	96	97	97
250 – Applies basic scientific information. Students at this level can interpret data from simple tables and make inferences about the outcomes of experimental procedures. They exhibit knowledge and understanding of the life sciences, including a familiarity with some aspects of animal behavior and of ecological relationships. These students also demonstrate some knowledge of basic information from the physical sciences.	9	26	24	28	31
	13	49	51	53	57
	17	82	77	81	81
300 – Analyzes scientific procedures and data. Students at this level can evaluate the appropriateness of the design of an experiment. They have more detailed scientific knowledge and the skill to apply their knowledge in interpreting information from text and graphs. These students also exhibit a growing understanding of principles from the physical sciences.	9	3	2	3	3
	13	11	10	9	11
	17	42	37	41	43
350 – Integrates specialized scientific information. Students at this level can infer relationships and draw conclusions using detailed scientific knowledge from the physical sciences, particularly chemistry. They also can apply basic principles of genetics and interpret the societal implications of research in this field.	9	0	0	0	0
	13	1	0	0	0
	17	9	7	8	9

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

See text table 1-1.

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Appendix table 1-3.

Percentage of students achieving at or above science proficiency levels, by age and race/ethnicity: 1977 and 1990 assessments

	Assessment years					
	1977			1990		
Proficiency level and age	White	Black	Hispanic	White	Black	Hispanic
	Percent					
Level 150						
9	98	72	85	99	88	94
13	100	93	94	100	99	99
17	100	99	100	100	99	100
Level 200						
9	77	27	42	84	46	56
13	92	57	62	97	78	80
17	99	84	93	99	88	92
Level 250						
9	31	4	9	38	9	12
13	57	15	18	67	24	30
17	88	41	62	90	51	60
Level 300						
9	4	0	0	4	0	0
13	13	1	2	14	2	3
17	48	8	19	51	16	21
Level 350						
9	0	0	0	0	0	0
13	1	0	0	1	0	0
17	10	0	2	11	2	2

NOTE: See appendix table 1-2 for a description of the proficiency levels.

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

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Appendix table 1-4.

Student achievement scores in mathematics, by age, gender, and race/ethnicity: 1973-90 assessments

Gender and race/ethnicity	1973	1978	1982	1986	1990
		9-year-olds			
Total	219.1	218.6	219.0	221.7	229.6
Male	217.7	217.4	217.1	221.7	229.1
Female	220.4	219.9	220.8	221.7	230.2
White	224.9	224.1	224.0	226.9	235.2
Black	190.0	192.4	194.9	201.6	208.4
Hispanic	202.1	202.9	204.0	205.4	213.8
		13-year-olds			
Total	266.0	264.1	268.6	269.0	270.4
Male	265.1	263.6	269.2	270.0	271.2
Female	266.9	264.7	268.0	268.0	269.6
White	273.7	271.6	274.4	273.6	276.3
Black	227.7	229.6	240.4	249.2	249.1
Hispanic	238.8	238.0	252.4	254.3	254.6
		17-year-olds			
Total	304.4	300.4	298.5	302.0	304.6
Male	308.5	303.8	301.5	304.7	306.3
Female	300.6	297.1	295.6	299.4	302.9
White	310.1	305.9	303.7	307.5	309.5
Black	269.8	268.4	271.8	278.6	288.5
Hispanic	277.2	276.3	276.7	283.1	283.5

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

See figures 1-4, 1-5, and 1-6, and figure O-12 in Overview.

Science & Engineering Indicators – 1991

Appendix table 1-5.
Percentage of students achieving at or above mathematics proficiency levels, by age: 1978-90 assessments

		Assessment years			
Level and description	Age	1978	1982	1986	1990
		Percent			
150 – Simple arithmetic facts. Students at this level know some basic addition and subtraction facts, and most can add two-digit numbers without regrouping. They recognize simple situations in which addition and subtraction apply. They also are developing rudimentary classification skills.	9....	97	97	98	99
	13....	100	100	100	100
	17....	100	100	100	100
200 – Beginning skills and understandings. Students at this level have considerable understanding of two-digit numbers. They can add two-digit numbers, but are still developing an ability to regroup in subtraction. They know some basic multiplication and division facts, recognize relations among coins, can read information from charts and graphs, and use simple measurement instruments. They are developing some reasoning skills.	9....	70	71	74	82
	13....	95	98	99	99
	17....	100	100	100	100
250 – Basic operations and beginning problem-solving. Students at this level have an initial understanding of the four basic operations. They are able to apply whole number addition and subtraction skills to one-step word problems and money situations. In multiplication, they can find the product of a two-digit and a one-digit number. They can also compare information from graphs and charts and are developing an ability to analyze simple logical relations.	9....	20	19	21	28
	13....	65	71	73	75
	17....	92	93	96	96
300 – Moderately complex procedures and reasoning. Students at this level are developing an understanding of number systems. They can compute with decimals, simple fractions, and commonly encountered percents. They can identify geometric figures, measure lengths and angles, and calculate areas of rectangles. These students are also able to interpret simple inequalities, evaluate formulas, and solve simple linear equations. They can find averages, make decisions on information drawn from graphs, and use logical reasoning to solve problems. They are developing the skills to operate with signed numbers, exponents, and square roots.	9....	1	1	1	1
	13....	18	17	16	17
	17....	52	49	52	56
350 – Multi-step problem-solving and algebra. Students at this level can apply a range of reasoning skills to solve multi-step problems. They can solve routine problems involving fractions and percents, recognize properties of basic geometric figures, and work with exponents and square roots. They can solve a variety of two-step problems using variables, identify equivalent algebraic expressions, and solve linear equations and inequalities. They are developing an understanding of functions and coordinate systems.	9....	0	0	0	0
	13....	1	1	0	0
	17....	7	6	7	7

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

See text table 1-2.

Science & Engineering Indicators – 1991

Appendix table 1-6.

Percentage of students achieving at or above mathematics proficiency levels, by age and race/ethnicity: 1978 and 1990 assessments

	Assessment years					
	1978			1990		
Proficiency level and age	White	Black	Hispanic	White	Black	Hispanic
	Percent					
Level 150						
9	98	88	93	100	97	98
13	100	99	100	100	100	100
17	100	100	100	100	100	100
Level 200						
9	76	42	54	87	60	68
13	98	80	86	99	95	97
17	100	99	99	100	100	100
Level 250						
9	23	4	9	33	9	11
13	73	29	36	82	49	57
17	96	71	78	98	92	86
Level 300						
9	1	0	0	2	0	0
13	21	2	4	21	4	6
17	58	17	23	63	33	30
Level 350						
9	0	0	0	0	0	0
13	1	0	0	0	0	0
17	9	1	1	8	2	2

NOTE: See appendix table 1-5 for a description of the proficiency levels.

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

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Appendix table 1-7.
Mathematics proficiency of eighth grade public school students, by region and state: 1990

	Average proficiency	Students at or above level			
		200	250	300	350
		Percent			
Nationwide	261	97	64	12	0
Regions					
Northeast	269	99	72	16	0
Southeast	253	94	52	8	0
Central	265	98	70	12	0
West	261	97	63	12	0
States[1]					
Alabama	252	96	52	7	0
Arizona	259	98	61	10	0
Arkansas	256	97	57	7	0
California	256	95	56	11	0
Colorado	267	99	72	14	0
Connecticut	270	98	72	19	0
Delaware	261	97	60	13	0
District of Columbia	231	86	23	2	0
Florida	255	96	54	10	0
Georgia	258	96	59	12	0
Hawaii	251	93	49	10	0
Idaho	272	100	79	15	0
Illinois	260	96	64	12	0
Indiana	267	99	71	14	0
Iowa	278	100	84	21	0
Kentucky	256	98	57	8	0
Louisiana	246	94	43	4	0
Maryland	260	96	61	14	0
Michigan	264	98	67	13	0
Minnesota	276	99	82	20	0
Montana	280	100	88	23	0
Nebraska	276	99	81	21	0
New Hampshire	273	100	79	17	0
New Jersey	269	99	72	19	0
New Mexico	256	98	56	8	0
New York	261	96	62	13	0
North Carolina	250	94	49	7	0
North Dakota	281	100	88	24	0
Ohio	264	98	67	12	0
Oklahoma	263	99	67	10	0
Oregon	271	99	76	18	0
Pennsylvania	266	98	69	15	0
Rhode Island	260	96	61	12	0
Texas	258	97	58	10	0
Virginia	264	98	64	15	1
West Virginia	256	98	56	7	0
Wisconsin	274	99	80	20	0
Wyoming	272	100	80	15	0
Territories					
Guam	231	81	28	3	0
Virgin Islands	218	76	11	0	0

[1] Data were reported by 38 states.

SOURCE: I.V.S. Mullis, J.A. Dossey, E.H. Own, and G.W. Phillips, *The State of Mathematics Achievement: NAEP's 1990 Assessment of the Nation and the Trial Assessment of the States* (Washington, DC: National Center for Education Statistics, 1991).

Science & Engineering Indicators – 1991

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Appendix table 1-8.

Intended majors of high school seniors scoring above the 90th percentile on the mathematics SAT: 1977-90

Intended major	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Percent													
All fields	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total science and engineering	40	44	46	46	47	50	49	46	46	44	48	47	46	46
Total sciences	27	28	28	27	27	29	28	26	26	23	25	26	26	26
Mathematics and statistics	5	5	4	4	4	3	3	3	3	3	3	3	3	3
Computer	3	4	5	5	7	9	10	9	7	4	4	3	3	3
Physical	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Life	5	5	5	4	4	4	4	4	4	4	5	6	6	6
Earth and environmental	1	1	1	1	1	1	1	1	1	1	*	*	*	*
Psychology	4	4	4	4	4	4	3	3	4	4	4	5	5	5
Social	3	4	4	3	3	3	2	2	2	2	3	3	3	3
Other	2	2	3	2	2	2	2	2	2	2	2	3	3	3
Total engineering	14	16	18	19	20	22	21	20	20	21	23	21	20	20
Total non-science/engineering	25	28	31	27	28	29	26	25	29	28	34	35	35	35
Humanities	6	6	7	5	6	6	5	4	5	5	6	6	6	6
Premedicine	8	8	8	8	8	8	8	8	9	7	8	7	7	7
Pre-law	2	4	4	3	3	3	3	3	3	3	3	4	4	4
Business	7	8	10	9	9	10	9	8	10	11	14	15	15	14
Education	3	2	2	2	2	2	1	1	2	2	3	3	3	3
Other, undecided, missing	34	28	23	27	26	21	26	29	25	28	18	19	19	19

* = less than 1 percent

SOURCE: J. Grandy, *Major Field Selections of High School Seniors Above the 90th Percentile in SAT Mathematics* (Princeton, NJ: Educational Testing Service, 1990), unpublished tabulations for the National Science Foundation.

See figures 1-8 and 1-9.

Science & Engineering Indicators - 1991

Appendix table 1-9.

Intended majors of white male high school seniors scoring above the 90th percentile on the mathematics SAT: 1977-90

Intended major	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Percent													
All fields	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total science and engineering	52	60	59	60	59	63	60	59	58	55	59	56	57	56
Total sciences	30	33	31	30	29	30	30	29	28	25	26	26	26	27
Mathematics and statistics	6	6	5	4	4	4	3	4	4	3	3	3	3	3
Computer	4	5	6	7	8	10	12	11	10	6	6	5	5	4
Physical	5	6	6	6	5	5	4	4	5	5	5	5	4	4
Life	4	5	4	4	3	3	3	3	3	3	4	4	4	4
Earth and environmental	1	2	1	1	1	1	1	1	1	1	*	*	*	*
Psychology	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Social	4	4	4	4	3	3	3	3	3	4	4	4	5	4
Other	5	5	5	4	4	4	3	3	3	2	3	4	4	4
Total engineering	22	27	28	29	29	32	30	29	30	30	33	30	31	29
Total non-science/engineering	23	27	26	25	23	22	20	21	23	22	30	29	29	29
Humanities	4	4	4	4	4	3	3	3	3	4	4	5	5	5
Premedicine	8	9	8	8	8	7	7	8	6	6	5	5	5	5
Pre-law	3	5	5	4	4	4	3	3	3	2	3	4	4	4
Business	7	8	9	8	8	8	7	7	9	9	13	14	14	14
Education	1	1	1	*	1	*	*	*	1	1	1	2	1	2
Other, undecided, missing	25	14	15	16	19	15	20	21	19	23	14	15	15	15

* = less than 1 percent

SOURCE: J. Grandy, *Major Field Selections of High School Seniors Above the 90th Percentile in SAT Mathematics* (Princeton, NJ: Educational Testing Servce, 1990), unpublished tabulations for the National Science Foundation.

Science & Engineering Indicators – 1991

Appendix table 1-10.

Intended majors of white female high school seniors scoring above the 90th percentile on the mathematics SAT: 1977-90

Intended major	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Percent													
All fields	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total science and engineering	32	32	37	34	37	41	40	37	39	34	37	37	37	37
Total sciences	27	26	29	26	28	30	29	27	29	25	27	28	28	29
Mathematics and statistics	5	5	4	4	4	4	4	4	4	3	3	3	3	3
Computer	2	3	4	4	6	8	8	6	4	2	2	2	1	1
Physical	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Life	7	7	7	5	6	6	5	5	6	6	7	7	7	8
Earth and environmental	1	1	1	1	1	1	1	1	1	1	*	*	*	*
Psychology	3	3	4	3	4	4	3	4	5	4	5	5	5	5
Social	5	4	5	4	4	4	4	4	5	5	6	7	7	7
Other	2	2	3	2	2	2	2	2	2	2	2	3	3	3
Total engineering	5	6	8	8	10	12	11	10	11	10	10	10	9	9
Total non-science/engineering	29	30	36	31	34	36	32	31	38	35	40	41	41	40
Humanities	9	9	10	8	8	9	8	7	9	8	9	9	10	9
Premedicine	7	6	7	7	7	8	8	8	8	7	7	6	6	6
Pre-law	2	3	3	3	4	4	3	3	4	3	4	4	4	5
Business	7	8	11	10	11	12	11	10	14	13	15	15	15	14
Education	5	4	4	3	4	3	3	3	4	4	5	6	6	7
Other, undecided, missing	38	38	27	37	29	23	28	33	23	31	22	22	22	22

* = less than 1 percent

SOURCE: J. Grandy, *Major Field Selections of High School Seniors Above the 90th Percentile in SAT Mathematics* (Princeton, NJ: Educational Testing Servce, 1990), unpublished tabulations for the National Science Foundation.

Appendix table 1-11.

Intended majors of black male high school seniors scoring above the 90th percentile on the mathematics SAT: 1977-90

Intended major	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Percent													
All fields	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total science and engineering	36	47	44	48	48	52	53	55	52	51	56	53	53	55
Total sciences	15	19	18	17	19	21	22	23	21	19	22	19	20	21
Mathematics and statistics	2	2	2	1	2	1	2	1	2	2	2	1	2	2
Computer	3	4	5	4	7	9	11	13	10	7	7	6	6	6
Physical	2	2	2	2	2	1	2	1	2	1	2	2	1	2
Life	2	3	3	2	3	3	3	3	2	3	4	3	3	3
Earth and environmental	*	1	1	1	*	*	*	*	*	*	*	*	*	*
Psychology	*	1	1	1	*	*	*	*	*	*	*	*	*	*
Social	3	3	3	3	2	2	2	2	3	3	3	3	3	3
Other	2	3	3	3	3	2	2	2	2	3	3	3	3	3
Total engineering	21	28	26	31	29	31	31	32	31	32	34	34	33	34
Total non-science/engineering	20	25	25	25	22	22	20	23	23	25	32	34	35	33
Humanities	3	3	3	3	2	2	2	2	2	3	3	3	3	3
Premedicine	8	8	7	8	7	8	7	8	7	6	8	6	7	7
Pre-law	2	3	4	3	2	3	3	3	3	2	3	4	5	5
Business	7	10	10	10	9	9	8	10	10	13	17	19	19	17
Education	1	1	1	1	*	*	*	1	1	*	1	1	1	1
Other, undecided, missing	44	29	30	28	31	26	27	22	25	25	12	13	13	13

* = less than 1 percent

SOURCE: J. Grandy, *Major Field Selections of High School Seniors Above the 90th Percentile in SAT Mathematics* (Princeton, NJ: Educational Testing Servce, 1990), unpublished tabulations for the National Science Foundation.

Science & Engineering Indicators – 1991

Appendix table 1-12.

Intended majors of black female high school seniors scoring above the 90th percentile on the mathematics SAT: 1977-90

Intended major	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Percent													
All fields	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total science and engineering	25	31	30	30	33	34	36	35	33	31	36	36	36	36
Total sciences	18	21	20	18	21	22	23	22	21	18	21	22	23	22
Mathematics and statistics	2	3	2	2	1	1	2	2	2	1	2	2	2	2
Computer	2	4	4	4	7	9	11	9	7	5	4	4	4	3
Physical	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Life	3	3	4	3	3	3	3	4	4	4	4	5	4	4
Earth and environmental	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Psychology	4	5	5	4	4	3	3	3	4	4	5	5	6	5
Social	4	5	4	3	3	3	3	3	3	3	4	5	5	5
Other	1	2	1	1	2	1	1	1	1	1	1	2	2	2
Total engineering	7	10	10	12	12	12	13	13	12	13	14	14	12	14
Total non-science/engineering	29	35	35	29	34	29	29	30	35	35	46	47	46	46
Humanities	5	6	6	4	5	4	3	3	4	4	4	5	5	5
Premedicine	10	11	11	10	12	11	11	11	12	12	14	12	12	13
Pre-law	3	5	5	4	5	4	4	4	4	4	6	7	8	7
Business	8	10	12	10	12	10	10	11	13	14	20	20	19	18
Education	3	3	3	1	1	1	1	1	1	1	2	3	3	3
Other, undecided, missing	46	35	34	42	34	37	35	35	32	34	18	17	18	18

* = less than 1 percent

SOURCE: J. Grandy, *Major Field Selections of High School Seniors Above the 90th Percentile in SAT Mathematics* (Princeton, NJ: Educational Testing Servce, 1990), unpublished tabulations for the National Science Foundation.

Science & Engineering Indicators – 1991

Appendix table 1-13.

Percentage of 17-year-old students studying science subject matter for 1 year or more: 1982, 1986, and 1990

Subject and student characteristic	1982	1986	1990
		Percent	
General science			
Total	61	69	56
Male	63	71	60
Female	59	67	53
White	61	71	56
Black	66	62	58
Hispanic	58	64	69
Life science			
Total	27	40	30
Male	29	45	32
Female	26	34	28
White	27	40	28
Black	27	40	35
Hispanic	31	41	44
Physical science			
Total	33	41	41
Male	33	43	42
Female	33	40	40
White	32	41	39
Black	34	45	47
Hispanic	35	37	55
Earth and space sciences			
Total	27	38	35
Male	30	41	35
Female	25	34	34
White	28	38	34
Black	28	44	35
Hispanic	20	23	38
Biology			
Total	76	80	85
Male	74	78	82
Female	78	82	87
White	78	81	86
Black	66	77	79
Hispanic	62	70	78
Chemistry			
Total	31	33	42
Male	31	34	40
Female	30	31	45
White	33	35	44
Black	19	23	36
Hispanic	13	16	26
Physics			
Total	11	11	10
Male	14	13	12
Female	9	8	9
White	11	11	9
Black	12	9	13
Hispanic	9	7	11

NOTE: Data are based on self-reports of 17-year-olds on different subjects studied for 1 year or more.

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

Science & Engineering Indicators – 1991

Appendix table 1-14.

Percentage of 17-year-old students by highest level of mathematics course taken: 1978 and 1990

Subject and student characteristic	1978	1990
	Percent	
Pre-algebra or general mathematics		
Total	20	15
Male	21	16
Female	20	14
White	18	15
Black	31	16
Hispanic	36	21
Algebra 1		
Total	17	15
Male	15	16
Female	18	15
White	17	15
Black	19	16
Hispanic	19	24
Geometry		
Total	16	15
Male	15	16
Female	18	14
White	17	15
Black	11	17
Hispanic	12	13
Algebra 2		
Total	37	44
Male	38	42
Female	37	47
White	39	46
Black	28	41
Hispanic	23	32
Precalculus or calculus		
Total	6	8
Male	7	8
Female	4	8
White	6	8
Black	4	6
Hispanic	3	7

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

Science & Engineering Indicators – 1991

Appendix table 1-15.

Estimated proportion of public high school students taking selected science courses by graduation, by state: fall 1989

(page 1 of 2)

State	Biology	Chemistry	Physics
		Percent	
U.S. total[1]	95+	45	20
Alabama	95+	38	21
Alaska	NA	NA	NA
Arizona	NA	NA	NA
Arkansas	95+	33	13
California	91	33	16
Colorado	NA	NA	NA
Connecticut	95+	62	36
Delaware	95+	48	19
District of Columbia	75	46	13
Florida	95+	44	19
Georgia	NA	NA	NA
Hawaii	88	40	21
Idaho	80	26	15
Illinois	78	40	20
Indiana	95+	42	19
Iowa	95+	57	27
Kansas	95+	45	17
Kentucky	95+	45	14
Louisiana	90	50	21
Maine	94	58	NA
Maryland	95+	61	27
Massachusetts	NA	NA	NA
Michigan	NA	NA	NA
Minnesota	95+	44	23
Mississippi	95+	55	17
Missouri	86	41	16
Montana	95+	48	24
Nebraska	95+	46	21
Nevada	65	33	13
New Hampshire	NA	NA	NA
New Jersey	NA	NA	NA
New Mexico	95+	33	15
New York	95+	56	28
North Carolina	95+	47	15
North Dakota	95+	54	24
Ohio	95+	49	20
Oklahoma	93	37	10
Oregon	NA	NA	NA
Pennsylvania	95+	56	29
Rhode Island	NA	NA	NA

(continued)

Appendix table 1-15.

Estimated proportion of public high school students taking selected science courses by graduation, by state: fall 1989

(page 2 of 2)

State	Biology	Chemistry	Physics
		Percent	
South Carolina	95+	51	16
South Dakota	NA	NA	NA
Tennessee	88	42	11
Texas	95+	40	12
Utah	80	37	20
Vermont	NA	NA	NA
Virginia	95+	57	23
Washington	NA	NA	NA
West Virginia	95+	40	11
Wisconsin	95+	51	25
Wyoming	86	36	16

NA = not available

NOTES: Each state proportion is a statistical estimate of coursetaking by high school students by the time they graduate. The estimate is based on the total course enrollment in grades 9-12 in fall 1989 divided by the estimated number of students in a grade cohort during 4 years of high school. The statistical estimation method is imprecise for states above 95-percent coursetaking rate.

[1] U.S. total is the proportion of public high school students estimated to take each course, including imputation for nonreporting states.

SOURCE: R.K. Blank and M. Dalkilic, *State Indicators of Science and Mathematics Education: 1990* (Washington, DC: Council of Chief State School Officers, 1991).

Science & Engineering Indicators – 1991

Appendix table 1-16.

Estimated proportion of public high school students taking selected mathematics courses by graduation, by state: fall 1989

(page 1 of 2)

State	Algebra 1[1]	Algebra 2	Calculus
	Percent		
U.S. total[2]	81	49	9
Alabama	70	46	6
Alaska	NA	NA	NA
Arizona	NA	NA	NA
Arkansas	88	48	5
California	92	44	9
Colorado	NA	NA	NA
Connecticut	74	61	14
Delaware	73	43	17
District of Columbia	65	39	3
Florida	78	42	9
Georgia	NA	NA	NA
Hawaii	52	33	4
Idaho	95+	64	6
Illinois	77	39	9
Indiana	60	45	8
Iowa	92	50	9
Kansas	66	47	9
Kentucky	81	54	6
Louisiana	95+	64	4
Maine	84	64	NA
Maryland	94	51	13
Massachusetts	NA	NA	NA
Michigan	NA	NA	NA
Minnesota	90	55	12
Mississippi	85	58	3
Missouri	95	58	8
Montana	94	65	6
Nebraska	75	54	6
Nevada	90	32	5
New Hampshire	NA	NA	NA
New Jersey	NA	NA	NA
New Mexico	95+	47	8
New York	69	46	12
North Carolina	67	51	8
North Dakota	95	64	3
Ohio	80	47	8
Oklahoma	95+	60	8
Oregon	NA	NA	NA
Pennsylvania	88	57	16
Rhode Island	NA	NA	NA

(continued)

Appendix table 1-16.

Estimated proportion of public high school students taking selected mathematics courses by graduation, by state: fall 1989

(page 2 of 2)

State	Algebra 1[1]	Algebra 2	Calculus
	Percent		
South Carolina	69	55	7
South Dakota	NA	NA	NA
Tennessee	79	54	4
Texas	82	54	5
Utah	82	63	13
Vermont	NA	NA	NA
Virginia	81	55	11
Washington	NA	NA	NA
West Virginia	73	42	2
Wisconsin	79	36	9
Wyoming	73	29	8

NA = not available

NOTES: Each state proportion is a statistical estimate of coursetaking by high school students by the time they graduate. The estimate is based on the total course enrollment in grades 9–12 in fall 1989 divided by the estimated number of students in a grade cohort during 4 years of high school. The statistical estimation method is imprecise for states above 95-percent coursetaking rate.

[1] Algebra 1 percentages include grade 8.

[2] U.S. total is the proportion of public high school students estimated to take each course, including imputation for nonreporting states.

SOURCE: R.K. Blank and M. Dalkilic, *State Indicators of Science and Mathematics Education: 1990* (Washington, DC: Council of Chief State School Officers, 1991).

Science & Engineering Indicators – 1991

Appendix table 1-17.

Average credits earned by public high school graduates in science, by gender and race/ethnicity: 1969-87

Subject and student characteristic	1969	1975-78	1979-81	1982	1987
			Percent		
All science credits					
Male	2.38	2.40	2.26	2.23	2.53
Female	2.10	2.14	2.11	2.11	2.49
White	2.28	NA	NA	2.25	2.57
Asian	2.38	NA	NA	2.57	3.00
Black	2.02	1.96	1.95	2.04	2.31
Hispanic	2.01	1.98	1.81	1.78	2.20
Native American	NA	NA	NA	1.96	2.44
Survey courses					
Male	0.92	0.56	0.57	0.78	0.78
Female	0.74	0.51	0.48	0.71	0.73
White	0.80	NA	NA	0.73	0.74
Asian	1.08	NA	NA	0.51	0.65
Black	0.87	0.55	0.54	0.82	0.90
Hispanic	0.99	0.51	0.33	0.77	0.77
Native American	NA	NA	NA	0.72	0.81
Biology					
Male	0.88	0.97	0.86	0.89	1.04
Female	0.99	0.99	0.98	0.96	1.13
White	0.94	NA	NA	0.96	1.11
Asian	0.69	NA	NA	1.08	1.11
Black	0.95	0.84	0.83	0.88	1.00
Hispanic	0.89	0.86	0.84	0.79	1.05
Native American	NA	NA	NA	0.77	1.22
Chemistry					
Male	0.42	0.42	0.37	0.35	0.47
Female	0.32	0.35	0.33	0.33	0.47
White	0.41	NA	NA	0.38	0.50
Asian	0.47	NA	NA	0.60	0.80
Black	0.17	0.22	0.21	0.25	0.31
Hispanic	0.11	0.34	0.24	0.15	0.28
Native American	NA	NA	NA	0.35	0.32
Physics					
Male	0.16	0.45	0.46	0.21	0.25
Female	0.06	0.29	0.32	0.12	0.16
White	0.13	NA	NA	0.19	0.22
Asian	0.15	NA	NA	0.39	0.43
Black	0.04	0.37	0.37	0.09	0.11
Hispanic	0.03	0.28	0.33	0.06	0.09
Native American	NA	NA	NA	0.11	0.09

SOURCE: J. Tuma, A. Gifford, D. Harde, E.G. Hoachlander, and L. Horn, *Course Enrollment Patterns in Public Secondary Schools, 1969 to 1987* (Berkeley, CA: MPR Associates, Inc., 1989).

Science & Engineering Indicators – 1991

Appendix table 1-18.

Average credits earned by public high school graduates in mathematics, by gender and race/ethnicity: 1969-87

Subject and student characteristic	1969	1975-78	1979-81	1982	1987
	Percent				
All mathematics credits					
Male	2.73	2.51	2.57	2.64	3.06
Female	2.23	2.21	2.31	2.47	2.97
White	2.52	NA	NA	2.60	3.03
Asian	3.12	NA	NA	3.14	3.70
Black	2.19	2.28	2.40	2.55	2.96
Hispanic	2.22	2.18	2.42	2.2	42.86
Native American	NA	NA	NA	2.09	3.06
Basic mathematics					
Male	0.33	0.17	0.10	0.11	0.14
Female	0.31	0.15	0.08	0.08	0.12
White	0.28	NA	NA	0.07	0.09
Asian	0.14	NA	N	0.08	0.09
Black	0.51	0.24	0.15	0.20	0.25
Hispanic	0.61	0.16	0.09	0.15	0.35
Native American	NA	NA	NA	0.26	0.10
General mathematics					
Male	0.25	0.45	0.51	0.50	0.38
Female	0.21	0.45	0.45	0.40	0.30
White	0.21	NA	NA	0.37	0.29
Asian	0.19	NA	NA	0.33	0.22
Black	0.33	0.74	0.80	0.72	0.63
Hispanic	0.33	0.52	0.52	0.68	0.44
Native American	NA	NA	NA	0.49	0.48
Algebra					
Male	0.85	0.64	0.65	0.55	0.66
Female	0.79	0.62	0.68	0.59	0.68
White	0.83	NA	NA	0.60	0.69
Asian	0.82	NA	NA	0.60	0.71
Black	0.77	0.50	0.57	0.47	0.59
Hispanic	0.67	0.66	0.67	0.45	0.59
Native American	NA	NA	NA	0.40	0.67
Geometry					
Male	0.57	0.50	0.50	0.45	0.57
Female	0.48	0.44	0.47	0.46	0.59
White	0.58	NA	NA	0.51	0.62
Asian	0.76	NA	NA	0.68	0.75
Black	0.27	0.26	0.27	0.30	0.43
Hispanic	0.27	0.35	0.40	0.24	0.40
Native American	NA	NA	NA	0.25	0.45
Calculus					
Male	0.01	0.03	0.03	0.05	0.07
Female	*	0.02	0.03	0.04	0.05
White	0.01	NA	NA	0.05	0.06
Asian	0.01	NA	NA	0.13	0.26
Black	*	0.01	0.01	0.02	0.03
Hispanic	*	0.01	0.02	0.02	0.03
Native American	NA	NA	NA	0.02	*

* = less than 0.01 credits; NA = not available

SOURCE: J. Tuma, A. Gifford, D. Harde, E.G. Hoachlander, and L. Horn, *Course Enrollment Patterns in Public Secondary Schools, 1969 to 1987* (Berkeley, CA: MPR Associates, Inc., 1989).

Appendix table 1-19.

Trends in mathematics classroom activities at age 17: 1978 and 1990

In your high school mathematics courses, how often did you:

	1978	1990
	Percent	
Listen to a teacher explain a mathematics lesson		
Often	79	84
Sometimes	19	13
Never	2	3
Discuss mathematics in class		
Often	51	63
Sometimes	43	31
Never	7	7
Watch the teacher work mathematics problems on the board		
Often	80	85
Sometimes	18	12
Never	2	3
Work mathematics problems on the board		
Often	28	28
Sometimes	60	52
Never	12	21
Make reports or do projects on mathematics		
Often	2	5
Sometimes	23	23
Never	75	72
Take mathematics tests		
Often	64	84
Sometimes	33	14
Never	3	2

SOURCE: I.V.S. Mullis, J.A. Dossey, M.A. Foertsch, L.R. Jones, C.A. Gentile, "Trends in Academic Progress: Achievement of American Students in Science, 1970-90, Mathematics, 1973-90, Reading, 1971-90, and Writing, 1984-90," review draft (Washington, DC: National Center for Education Statistics, August 1991).

Science & Engineering Indicators – 1991

Appendix table 1-20.

Frequency of scientific experiments conducted in public school eighth grade science classes, by student background: 1988

Student characteristic	Number of science experiments			
	0 or <1 per month	About 1 per month	About 1 per week	About 1 per day
	Percentage of students reporting			
Total	20.6	20.4	46.9	12.1
Socioeconomic status				
Low	29.2	21.3	41.0	8.5
Middle	20.4	21.7	46.9	11.0
High	11.6	16.2	53.5	18.7
Race/ethnicity				
White	19.7	20.0	47.4	12.9
Asian/Pacific Islander	13.8	17.6	48.2	20.5
Black	23.2	24.1	43.3	9.5
Hispanic	24.6	21.8	22.5	8.4
Native American/Alaskan Native	34.5	16.0	44.3	5.2

SOURCE: A. Hafner and L. Horn, *Survey Report: A Profile of American Eighth Grade Mathematics and Science Instruction* (Washington, DC: National Center for Education Statistics, in press).

Science & Engineering Indicators – 1991

Appendix table 1-21.
Elementary school class time spent on science and mathematics, by state: 1990

State	Science		Mathematics	
	Grades 1-3	Grades 4-6	Grades 1-3	Grades 4-6
	Hours/week			
Median	2.3	3.0	4.8	4.9
Alabama	2.8	3.7	4.8	4.8
Alaska	2.3	3.0	4.7	4.7
Arizona	2.2	3.2	5.0	5.3
Arkansas	2.4	3.4	5.0	5.0
California	2.5	2.7	4.9	4.7
Colorado	2.6	3.2	5.0	4.9
Connecticut	2.0	3.0	5.0	5.3
Delaware	1.8	2.3	4.7	4.4
District of Columbia	2.9	3.0	6.0	4.8
Florida	2.6	3.2	4.9	4.9
Georgia	2.6	3.3	4.6	4.9
Hawaii	2.3	2.8	4.5	5.5
Idaho	2.5	2.9	4.7	4.9
Illinois	2.2	3.3	4.6	4.8
Indiana	2.9	3.2	5.7	4.5
Iowa	2.2	2.7	4.3	5.0
Kansas	2.2	3.1	4.8	4.9
Kentucky	2.9	3.5	5.0	4.7
Louisiana	3.3	3.6	4.6	5.4
Maine	2.7	3.0	4.7	4.7
Maryland	2.0	2.9	5.3	5.0
Massachusetts	1.8	2.3	5.2	5.4
Michigan	2.7	2.8	4.9	5.0
Minnesota	2.4	2.3	4.4	4.7
Mississippi	2.8	2.4	5.2	6.0
Missouri	2.3	3.6	5.2	4.9
Montana	2.1	3.3	4.6	3.8
Nebraska	2.2	3.5	4.3	4.9
Nevada	1.9	3.2	4.9	4.8
New Hampshire	2.0	4.1	4.6	5.0
New Jersey	2.1	2.4	4.6	5.2
New Mexico	2.6	3.5	5.3	5.4
New York	2.2	3.0	5.0	4.8
North Carolina	2.9	3.8	4.8	5.3
North Dakota	2.3	3.4	4.7	4.7
Ohio	2.1	3.3	4.2	4.1
Oklahoma	2.3	3.1	4.6	4.3
Oregon	2.2	3.0	5.0	4.7
Pennsylvania	2.1	2.7	4.7	4.7
Rhode Island	1.3	2.4	4.8	4.8
South Carolina	2.4	3.4	5.0	5.1
South Dakota	2.7	3.5	5.0	5.1
Tennessee	2.4	2.8	4.9	5.5
Texas	3.5	4.0	5.1	5.1
Utah	2.1	2.2	4.9	5.0
Vermont	2.8	2.9	5.2	4.8
Virginia	2.4	3.0	5.2	5.2
Washington	1.9	2.6	4.7	4.5
West Virginia	1.9	3.0	4.7	4.6
Wisconsin	2.4	2.9	4.5	5.4
Wyoming	2.7	3.7	4.5	4.6

SOURCE: R.K. Blank and M. Dalkilic, *State Indicators of Science and Mathematics Education: 1990* (Washington, DC: Council of Chief State School Officers, 1991).

Science & Engineering Indicators – 1991

Appendix table 1-22.

Public school eighth graders in mathematics classes with algebra or fractions taught as major topic, by student background: 1988

Student characteristic	Algebra	Fractions
	—Percentage of students reporting—	
Total	62.0	64.3
Socioeconomic status		
Low	49.3	79.2
Middle	59.1	68.1
High	74.8	52.4
Race/ethnicity		
White	62.3	63.8
Asian/Pacific Islander	67.4	54.6
Black	48.5	80.4
Hispanic	57.5	80.6
Native American/Alaskan Native	48.3	82.9

SOURCE: A. Hafner and L. Horn, *Survey Report: A Profile of American Eighth Grade Mathematics and Science Instruction* (Washington, DC: National Center for Education Statistics, in press).

Science & Engineering Indicators – 1991

Appendix table 1-23.

Federal FY 1992 budget, by agency and major program area

		Program areas				
Agency	Total precollege	Teacher preparation & enhancement	Curriculum development[1]	Comprehensive/ organization reform	Student incentives	Other
	—Millions of dollars—					
Total	660.62	358.53	137.27	57.57	47.75	59.50
National Science Foundation	253.05	97.30	84.75	47.55	11.00	12.45
Education	313.80	239.00	34.80	0.00	0.00	40.00
Energy	21.65	6.20	1.90	6.40	5.75	1.40
Defense	4.97	0.63	0.00	0.00	4.34	0.00
Commerce	0.55	0.25	0.09	0.00	0.21	0.00
National Aeronautics and Space	14.10	5.57	5.60	0.28	0.55	2.10
Interior	21.96	2.06	3.60	0.50	14.32	1.49
Health and Human Services	21.77	5.15	4.52	0.60	10.87	0.62
Environmental Protection	8.07	2.37	2.01	2.04	0.21	1.44
Agriculture	0.70	0.00	0.00	0.20	0.50	0.00

[1] Includes program assessment and evaluation.

SOURCE: Federal Coordinative Council for Science, Engineering, and Technology, *By the Year 2000: Report of the FCCSET Committee on Education and Human Resources*, budget summary, FY 1992 (Washington, DC: Office of Science and Technology Policy, 1991).

Science & Engineering Indicators – 1991

Appendix table 2-1.
Number of institutions awarding baccalaureates, by Carnegie classification: 1988

Carnegie category	Number of institutions: Total	Number of institutions: Total S&E	Number of institutions: Natural sciences	Number of institutions: Social sciences & psychology	Number of institutions: Engineering	Number of institutions: S&E technologies	Number of degrees: Total S&E	Number of degrees: Natural sciences	Number of degrees: Social sciences & psychology	Number of degrees: Engineering	Number of degrees: S&E technologies
Total	1,739	1,392	1,331	1,222	370	302	327,999	123,115	115,239	70,406	19,239
Research I	69	67	67	66	63	18	97,541	33,503	33,429	28,452	2,157
Research II	34	34	34	34	28	11	30,841	10,162	10,948	8,476	1,255
Doctorate-granting I	48	47	46	47	31	19	25,605	8,843	9,468	5,826	1,468
Doctorate-granting II	56	54	54	50	36	17	24,662	8,477	6,904	7,928	1,353
Comprehensive I	395	394	393	379	120	149	95,257	39,596	32,884	14,706	8,071
Comprehensive II	165	163	162	150	20	25	10,574	5,458	4,013	623	480
Liberal arts I	141	138	138	135	18	3	19,856	7,238	12,027	588	3
Liberal arts II	413	380	357	339	24	25	11,409	5,803	4,987	351	268
Two-year institution	27	15	8	2	1	7	591	39	16	129	407
Specialized	333	83	60	14	20	24	8,691	2,995	100	2,233	3,363
Other	20	11	8	4	8	0	2,221	692	439	1,090	0
Not classified	38	6	4	2	1	4	751	309	24	4	414

NOTE: S&E = science and engineering.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations from the Completion Survey conducted by the National Center for Education Statistics.

See figure 2-1 and text table 2-1.

Science & Engineering Indicators – 1991

Appendix table 2-2.

Number of institutions awarding masters degrees, by Carnegie classification: 1988

	Number of institutions						Number of degrees				
Carnegie category	Total	Total S&E	Natural sciences	Social sciences & psychology	Engineering	S&E technologies	Total S&E	Natural sciences	Social sciences & psychology	Engineering	S&E technologies
Total	1,172	645	529	476	242	56	64,721	26,809	14,197	22,891	824
Research I	69	68	68	66	65	6	26,094	10,527	3,805	11,688	74
Research II	34	34	34	34	28	3	7,836	3,356	1,368	3,044	68
Doctorate-granting I	49	48	46	48	25	7	6,289	2,690	1,695	1,758	146
Doctorate-granting II	57	57	53	45	31	7	6,264	2,723	1,238	2,215	88
Comprehensive I	356	275	233	199	68	27	13,532	6,201	4,239	2,735	357
Comprehensive II	111	43	23	26	4	3	870	163	625	72	10
Liberal arts I	49	28	20	17	2	0	661	154	471	36	0
Liberal arts II	131	26	9	21	1	0	339	69	269	1	0
Two-year institution	1	0	0	0	0	0	0	0	0	0	0
Specialized	266	45	37	5	13	2	1,524	764	75	680	5
Other	30	19	5	14	4	1	1,292	157	406	653	76
Not classified	19	2	1	1	1	0	20	5	6	9	0

NOTE: S&E = science and engineering.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations from the Completion Survey conducted by the National Center for Education Statistics..

See figure 2-1 and text table 2-1.

Science & Engineering Indicators – 1991

Appendix table 2-3.

Number of institutions awarding doctorates, by Carnegie classification: 1988

	Number of institutions						Number of degrees				
Carnegie category	Total	Total S&E	Natural sciences	Social sciences & psychology	Engineering	S&E technologies	Total S&E	Natural sciences	Social sciences & psychology	Engineering	S&E technologies
Total	343	291	254	221	160	0	20,762	10,434	6,139	4,189	0
Research I	70	70	70	69	64	0	13,569	7,159	3,366	3,044	0
Research II.	34	34	34	34	27	0	3,196	1,592	1,014	590	0
Doctorate-granting I.	49	48	47	47	22	0	2,016	786	986	244	0
Doctorate-granting II	55	52	42	39	27	0	1,033	454	348	231	0
Comprehensive I.	57	35	25	11	12	0	233	115	76	42	0
Comprehensive II	4	2	1	1	1	0	32	9	16	7	0
Liberal arts I	6	3	2	2	0	0	33	17	16	0	0
Liberal arts II.	2	1	1	1	0	0	5	3	2	0	0
Two-year institution	0	0	0	0	0	0	0	0	0	0	0
Specialized.	53	33	29	7	4	0	343	278	51	14	0
Other	13	13	3	10	3	0	302	21	264	17	0
Not classified	0	0	0	0	0	0	0	0	0	0	0

NOTE: S&E = science and engineering.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations from the Completion Survey conducted by the National Center for Education Statistics.

See figure 2-1 and text table 2-1.

Science & Engineering Indicators – 1991

Appendix table 2-4.

Baccalaureate institutions of 1985-90 doctorate recipients, by Carnegie classification and field of doctorate

Field of doctorate	Total	Research universities[1]	Other doctorate-granting universities[2]	Comprehensive institutions[3]	Liberal arts colleges[4]	Specialized schools
	Percent					
Total science and engineering	100	40	25	20	14	2
Total sciences	100	38	25	21	15	1
Physical sciences	100	37	22	24	16	2
Mathematics	100	40	23	19	16	2
Computer sciences	100	46	25	17	10	3
Environmental sciences	100	42	27	14	15	1
Agricultural sciences	100	47	29	17	7	0
Biological sciences	100	41	24	20	15	1
Psychology	100	32	26	25	16	1
Social sciences	100	36	25	21	17	1
Total engineering	100	53	28	11	4	4

[1] Includes research I and II universities.

[2] Includes doctorate-granting I and II universities.

[3] Includes comprehensive I and II institutions.

[4] Includes liberal arts I and II colleges.

SOURCE: Science Resources Studies Division, National Science Foundation, *Undergraduate Origins of Recent Science and Engineering Doctorate Recipients*, special report (Washington, DC: NSF, forthcoming).

Science & Engineering Indicators – 1991

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Appendix table 2-5.

Selected characteristics of American college freshmen: 1971-90

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	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Freshmen planning to major in science and engineering fields																			
	Percent																			
Average grade in high school																				
A or A+	11.1	12.3	15.3	16.1	16.6	17.9	16.5	19.6	18.6	18.8	18.1	18.5	18.8	18.3	20.3	21.9	21.8	20.8	20.2	19.8
A-	15.2	16.6	16.7	18.6	18.3	19.2	17.3	19.8	18.1	18.3	17.6	17.2	17.6	17.3	19.7	19.2	17.5	18.9	19.3	18.9
B+	23.0	24.8	26.1	24.3	24.1	24.7	23.3	22.3	21.3	21.3	22.1	22.1	22.1	22.1	21.9	20.8	21.6	20.1	20.6	20.7
B	24.1	24.3	22.9	22.3	21.9	21.5	22.8	20.9	22.0	22.0	22.2	22.1	21.2	21.7	20.4	19.4	18.1	20.7	21.6	21.1
B-	13.1	11.1	10.5	9.4	10.0	8.7	10.0	8.9	9.9	9.5	10.2	9.9	9.7	10.0	8.9	9.4	11.6	9.7	9.7	10.1
C+	9.0	7.5	5.5	6.1	5.7	5.4	6.6	5.6	6.8	6.5	6.4	6.9	7.1	6.8	5.4	6.3	5.2	6.5	6.0	6.4
C	4.2	3.3	2.9	3.0	3.3	2.5	3.3	2.8	3.2	3.4	3.2	3.1	3.4	3.7	3.2	3.0	3.9	3.2	2.5	3.0
D	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1
Father's education																				
Grammar school or less	6.7	6.5	4.8	5.2	4.6	4.7	5.1	4.1	4.3	4.2	3.6	3.5	3.4	3.2	2.8	2.5	2.4	2.6	2.4	2.8
Some high school	12.6	11.6	9.5	9.5	9.2	8.8	9.0	8.1	8.1	8.1	7.5	7.1	7.1	6.3	6.0	5.4	5.3	5.0	5.1	5.3
High school graduate	27.6	27.4	22.3	23.1	23.0	22.7	23.5	21.8	22.6	22.0	22.8	22.9	22.9	22.6	19.8	19.5	19.4	19.6	20.3	20.6
Postsecondary (not college)	NA	NA	4.7	4.6	4.3	4.2	4.4	4.5	4.3	4.3	4.3	4.5	4.8	5.1	5.0	4.7	5.0	5.0	5.2	5.2
Some college	17.5	16.9	15.2	14.2	14.1	13.6	13.7	14.0	14.0	13.7	13.9	14.1	14.2	14.2	13.5	14.5	13.9	14.7	14.9	14.9
College degree	22.4	19.5	21.0	21.5	21.9	22.3	21.9	22.8	22.1	22.6	22.7	22.8	22.5	22.5	22.7	23.4	23.3	23.0	24.0	23.3
Some graduate school	NA	3.3	3.7	3.6	3.4	3.8	3.4	3.8	3.7	3.5	3.6	3.5	3.4	3.8	4.2	4.2	4.2	4.0	3.5	3.6
Graduate degree	13.2	14.7	18.8	18.3	19.6	19.8	19.0	20.9	20.9	21.6	21.7	21.6	21.7	22.4	26.0	25.8	26.5	26.2	24.6	24.2
Mother's education																				
Grammar school or less	4.0	4.0	2.8	3.4	3.0	2.9	3.2	2.7	3.0	2.7	2.3	2.3	2.2	2.1	2.0	1.8	2.0	1.9	1.9	2.3
Some high school	10.9	9.6	7.9	8.2	7.7	7.5	7.9	6.9	7.1	6.7	6.3	6.0	5.7	5.4	4.8	4.3	3.8	4.0	3.7	4.1
High school graduate	42.7	42.2	36.8	36.7	36.7	36.2	36.9	36.0	35.4	34.4	34.7	34.0	34.2	32.8	29.9	28.1	27.4	26.8	27.3	27.2
Postsecondary (not college)	NA	NA	8.2	8.2	7.9	8.0	7.7	7.6	7.8	7.5	7.3	8.0	7.9	8.3	7.6	8.1	8.3	7.7	8.3	7.7
Some college	19.8	19.7	17.2	16.4	16.1	15.9	15.9	16.1	16.3	16.9	16.8	16.6	16.5	16.9	17.3	18.5	17.7	18.5	18.3	18.2
College degree	18.2	16.5	17.5	18.1	18.5	19.1	18.2	19.5	19.0	19.7	20.6	20.8	20.3	21.0	22.2	22.8	23.3	23.2	23.4	23.4
Some graduate school	NA	3.0	3.3	3.1	3.1	3.1	3.0	3.4	3.2	3.3	3.4	3.2	3.4	3.5	4.3	4.4	4.6	4.6	4.1	3.9
Graduate degree	4.4	5.0	6.3	6.0	6.9	7.2	7.1	7.8	8.2	8.7	8.7	9.1	9.6	10.0	11.9	12.0	13.0	13.4	13.1	13.2
Father's occupation																				
Artist (including performer)	0.7	0.8	NA	NA	NA	0.9	0.9	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.7	0.7
Businessman	30.5	31.1	NA	NA	NA	30.3	29.0	29.3	28.8	29.1	29.2	29.3	28.6	29.0	29.0	30.1	30.1	28.9	28.8	27.7
Clergy or religious worker	1.0	1.1	NA	NA	NA	1.3	1.3	1.1	1.2	1.3	1.1	1.2	1.1	1.0	1.1	1.2	1.2	1.1	1.2	1.2
College teacher	1.2	1.3	NA	NA	NA	1.5	1.5	1.6	1.6	1.7	1.5	1.6	1.5	1.7	2.0	1.8	1.7	1.7	1.5	1.3
Doctor or dentist	2.4	2.4	NA	NA	NA	4.0	3.3	3.3	3.4	3.5	3.6	3.6	3.4	3.4	3.8	3.5	3.8	3.6	3.3	3.3
Education (secondary)	2.3	2.7	NA	NA	NA	3.4	3.4	3.6	3.7	3.8	4.0	4.0	4.1	3.9	4.2	4.2	4.3	4.3	4.3	4.1
Education (elementary)	0.3	0.4	NA	NA	NA	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0
Engineer	9.6	10.2	NA	NA	NA	11.8	11.3	12.4	11.5	11.5	11.4	11.4	11.2	11.2	11.9	11.5	11.2	10.7	10.4	10.0
Farmer or forester	4.5	3.7	NA	NA	NA	3.0	2.3	2.3	2.1	2.6	2.6	2.5	2.3	2.3	2.3	2.2	2.2	2.1	2.4	2.4

(continued)

Appendix table 2-5.

Selected characteristics of American college freshmen: 1971-90

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	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Freshmen planning to major in science and engineering fields																				
Percent																				
Health professional (non-MD)	1.2	1.1	NA	NA	NA	1.3	1.3	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.2
Lawyer	1.5	1.7	NA	NA	NA	2.0	2.1	2.1	2.2	2.2	2.2	2.1	2.2	2.2	2.5	2.3	2.4	2.5	2.2	2.2
Military (career)	2.7	2.5	NA	NA	NA	2.7	2.9	2.9	2.8	2.9	2.8	2.7	2.5	2.5	2.2	2.7	2.4	2.4	2.6	2.4
Research scientist	1.1	1.1	NA	NA	NA	1.3	1.1	1.2	1.1	1.2	1.1	1.0	1.0	1.1	1.4	1.2	1.2	1.1	1.0	0.9
Skilled worker	11.4	11.6	NA	NA	NA	9.6	10.1	9.7	9.8	9.5	10.1	9.7	9.3	9.6	8.3	8.3	8.6	8.9	9.1	9.0
Semi-skilled worker	7.0	6.5	NA	NA	NA	4.7	5.4	4.4	4.7	4.5	4.1	4.2	4.7	4.2	3.8	3.5	3.4	3.7	3.8	3.9
Laborer (unskilled)	3.2	3.4	NA	NA	NA	2.7	2.7	2.6	2.9	2.7	2.5	2.5	2.5	2.4	2.5	2.3	2.0	2.2	2.2	2.7
Unemployed	1.1	1.7	NA	NA	NA	1.9	1.9	1.9	1.8	2.0	1.5	1.7	2.6	2.1	2.2	2.1	1.7	1.9	2.1	2.2
Other	18.1	16.7	NA	NA	NA	17.0	18.9	18.7	19.5	18.9	19.4	19.5	20.1	20.5	19.7	20.0	20.5	21.6	21.9	23.7
Mother's occupation																				
Artist (including performer)	0.9	0.9	NA	NA	NA	1.4	1.5	1.4	1.5	1.4	1.6	1.6	1.7	1.7	1.9	1.9	1.8	1.9	1.7	1.7
Businesswoman	4.6	5.5	NA	NA	NA	6.3	6.6	7.6	7.8	8.7	9.7	10.1	10.3	11.3	12.9	13.6	14.3	14.5	14.6	13.9
Business (clerical)	8.7	11.0	NA	NA	NA	9.7	9.5	9.9	10.0	10.7	10.8	10.6	10.6	10.7	9.9	10.8	10.4	9.8	10.3	9.8
Clergy or religious worker	0.1	0.1	NA	NA	NA	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
College teacher	0.4	0.4	NA	NA	NA	0.6	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.7	0.6	0.7	0.7	0.7	0.7
Doctor or dentist	0.1	0.1	NA	NA	NA	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.7	0.5	0.5	0.6	0.5	0.6
Education (secondary)	2.6	3.1	NA	NA	NA	3.5	3.4	3.5	3.6	3.9	4.3	4.4	4.0	4.2	4.9	5.0	5.2	5.3	5.2	5.2
Education (elementary)	4.9	5.1	NA	NA	NA	6.6	6.6	6.7	6.5	6.9	7.1	7.1	6.6	6.5	7.2	7.4	7.8	7.9	8.1	8.0
Engineer	0.1	0.0	NA	NA	NA	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Farmer or forester	0.1	0.2	NA	NA	NA	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.4
Health professional (non-MD)	1.1	1.2	NA	NA	NA	1.7	1.7	1.6	1.8	1.9	2.0	1.9	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.3
Homemaker (full-time)	52.5	35.5	NA	NA	NA	35.2	32.3	32.0	29.8	28.0	23.4	22.8	25.0	23.6	21.4	19.9	17.7	16.7	15.7	14.4
Lawyer	0.1	0.1	NA	NA	NA	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Nurse	4.5	4.7	NA	NA	NA	6.6	6.7	6.6	6.9	6.9	7.6	8.2	7.5	7.4	7.6	7.7	8.0	7.9	8.0	7.8
Research scientist	0.1	0.1	NA	NA	NA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.2
Social/welfare worker	0.8	1.0	NA	NA	NA	1.3	1.4	1.3	1.6	1.4	1.4	1.5	1.4	1.6	1.5	1.6	1.6	1.8	1.6	1.7
Skilled worker	1.3	1.8	NA	NA	NA	1.6	1.7	1.8	1.7	1.8	1.8	1.9	1.7	2.0	1.9	1.9	2.2	2.0	2.2	2.2
Semi-skilled worker	2.8	3.3	NA	NA	NA	2.9	3.1	2.8	3.2	2.9	3.2	3.1	3.1	2.8	2.8	2.5	2.5	2.4	2.8	2.7
Laborer (unskilled)	1.4	1.8	NA	NA	NA	1.7	2.0	1.8	1.9	1.9	2.0	1.8	1.9	1.6	1.7	1.6	1.5	1.6	1.5	1.7
Unemployed	3.3	11.8	NA	NA	NA	8.0	8.2	7.8	7.5	7.4	7.4	7.0	6.3	5.9	5.8	5.5	5.6	5.3	4.9	5.2
Other	9.6	12.3	NA	NA	NA	12.1	13.9	13.7	14.6	14.6	16.1	16.2	15.8	16.3	15.6	15.9	16.8	18.0	18.4	20.4
Student's probable career																				
Accountant or actuary	0.5	0.6	NA	NA	NA	0.4	0.4	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.6	0.7
Architect	0.2	0.3	NA	NA	NA	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.3	0.4	0.4	0.4	0.4
Business (management)	1.3	1.2	NA	NA	NA	1.5	1.5	1.8	1.9	1.8	2.0	2.0	2.2	2.2	3.0	2.8	2.7	2.6	2.3	2.0
Clinical psychologist	4.8	4.6	NA	NA	NA	3.8	3.8	3.8	4.3	3.7	3.5	3.2	3.4	4.2	4.3	5.3	5.7	6.4	5.8	5.5
College teacher	1.0	0.9	NA	NA	NA	0.4	0.4	0.2	0.3	0.2	0.3	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.5
Computer programmer	2.6	2.6	NA	NA	NA	3.4	4.1	5.7	6.8	9.0	12.4	15.2	14.4	10.6	7.1	5.9	5.3	4.9	4.9	4.7
Conservationist or forester	1.1	1.4	NA	NA	NA	1.7	1.7	1.3	1.3	1.0	1.0	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.9	0.9

(continued)

Appendix table 2-5.

Selected characteristics of American college freshmen: 1971-90

(page 3 of 7)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Freshmen planning to major in science and engineering fields																				
	Percent																			
Engineer	16.6	18.0	NA	NA	NA	22.5	27.3	27.8	29.0	32.2	31.1	33.2	31.2	30.4	30.7	29.7	28.6	26.2	28.1	27.6
Farmer or rancher	0.2	0.3	NA	NA	NA	0.3	0.3	0.2	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.2	0.1
Foreign service worker	1.2	1.2	NA	NA	NA	1.3	1.4	1.4	1.4	1.5	1.3	1.4	1.6	2.0	3.1	2.9	3.1	3.3	2.7	2.4
Lawyer	4.2	5.4	NA	NA	NA	8.5	9.0	8.1	7.9	7.8	7.3	7.1	6.7	6.9	7.1	7.0	8.2	9.9	9.4	9.7
Military service (career)	3.6	4.3	NA	NA	NA	2.8	3.3	3.7	3.8	3.2	3.3	2.5	3.4	3.8	2.9	4.3	3.2	2.3	2.4	2.3
Nurse	0.1	0.1	NA	NA	NA	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.2
Physician	2.0	3.1	NA	NA	NA	10.7	5.8	6.1	6.1	6.1	6.0	6.5	7.0	7.0	8.0	6.8	7.0	6.8	5.9	6.7
School counselor	1.2	0.9	NA	NA	NA	0.7	0.7	0.4	0.6	0.4	0.5	0.4	0.5	0.5	0.5	0.7	0.7	0.8	0.7	0.8
Scientific researcher	9.8	9.4	NA	NA	NA	9.0	8.9	8.3	7.0	6.2	5.8	5.0	5.2	5.4	5.7	5.8	5.8	6.0	6.1	5.8
Social worker	9.8	8.8	NA	NA	NA	6.8	6.9	6.2	5.8	4.9	4.0	2.9	2.8	3.1	3.1	3.2	3.4	3.8	3.1	3.1
Statistician	0.4	0.4	NA	NA	NA	0.3	0.3	0.3	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Therapist (e.g., physical)	0.4	0.4	NA	NA	NA	0.4	0.5	0.4	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.8	0.8	0.8
Teacher (elementary)	1.8	1.5	NA	NA	NA	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.4
Teacher (secondary)	6.7	5.0	NA	NA	NA	1.3	1.0	0.8	0.7	0.6	0.6	0.6	0.8	1.2	1.4	1.3	1.3	1.4	1.4	1.4
Veterinarian	0.5	0.6	NA	NA	NA	2.2	1.3	1.2	1.1	1.1	1.0	1.0	0.9	1.0	0.9	1.0	1.0	0.9	0.8	0.9
Writer or journalist	0.4	0.3	NA	NA	NA	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.4	0.4
Skilled trades	0.5	0.4	NA	NA	NA	0.2	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.4
Other	7.0	6.7	NA	NA	NA	5.2	5.9	5.8	5.8	5.4	5.4	4.7	4.8	5.4	5.5	5.9	6.4	7.2	8.5	9.1
Undecided	17.6	16.9	NA	NA	NA	9.1	8.8	9.9	8.8	8.3	8.1	7.5	8.0	8.7	8.8	9.2	9.1	8.9	8.9	9.0
Student's probable major																				
Biological sciences	14.5	16.7	26.7	24.9	24.3	24.9	19.1	18.2	16.4	14.9	14.6	13.7	14.8	15.6	14.8	15.7	15.7	15.4	15.1	16.1
Engineering	21.2	22.3	17.4	23.1	25.9	26.3	31.9	33.0	34.9	38.0	36.4	37.7	35.8	35.3	35.7	34.8	33.4	30.4	32.8	32.3
Mathematics or statistics	12.1	10.0	6.9	5.9	4.6	4.3	3.9	4.0	3.1	3.0	3.1	3.0	3.6	3.7	3.6	3.3	3.1	2.7	2.8	2.8
Computer sciences	2.3	2.5	1.5	2.3	2.4	2.8	3.2	4.8	6.2	8.6	12.4	15.4	15.3	11.1	7.9	6.5	5.8	5.4	5.5	5.5
Physical sciences	8.8	8.4	10.4	10.1	10.5	10.6	9.7	9.7	9.0	7.7	7.9	6.8	6.8	6.8	7.1	6.9	6.5	6.6	6.6	6.7
Social sciences	25.9	25.7	25.1	22.8	21.7	21.5	22.4	20.6	20.2	18.7	16.8	14.9	14.8	16.7	19.0	19.0	20.5	23.2	21.5	21.5
Psychology	15.3	14.5	12.0	11.0	10.6	9.5	9.8	9.7	10.3	9.1	8.8	8.4	8.9	10.8	11.8	13.8	15.0	16.2	15.6	15.1
Other technical	2.3	2.5	1.5	2.3	2.4	2.8	3.2	4.8	6.2	8.6	12.4	15.4	15.3	11.1	7.9	6.5	5.8	5.4	5.5	5.5
Highest degree planned																				
None	NA	1.0	NA	1.0	1.1	1.0	0.8	0.7	0.5	0.9	0.7	0.7	1.2	0.9	1.1	1.1	1.1	0.9	0.6	0.7
Associate or equivalent	NA	0.6	NA	0.5	0.5	0.4	0.8	0.7	1.0	0.7	0.7	1.1	0.5	0.5	0.3	0.3	0.2	0.3	0.3	0.3
Bachelors	NA	31.3	NA	24.6	22.8	22.7	23.8	25.1	24.2	26.0	26.8	27.4	25.5	24.9	22.5	22.2	20.4	18.0	18.9	18.5
Masters	NA	36.9	NA	29.7	31.4	31.8	34.5	35.6	37.3	36.1	37.1	36.6	36.8	36.7	36.5	37.7	37.5	37.1	38.1	37.1
Doctorate	NA	19.4	NA	18.6	18.7	18.5	20.6	19.5	19.0	18.0	17.4	16.8	18.0	19.5	21.8	22.5	23.3	24.9	24.6	24.6
Professional (e.g., MD, DDS)	NA	4.8	NA	16.3	15.6	15.6	9.1	9.3	9.4	9.4	9.1	9.3	9.7	9.6	10.3	9.0	9.1	8.9	8.2	9.1
Law	NA	5.1	NA	8.2	8.5	8.5	8.8	7.8	7.5	7.4	7.0	6.8	6.4	6.3	6.7	6.1	7.4	8.8	8.4	8.6
Divinity	NA	0.3	NA	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.2	0.2	0.2	0.3	0.2	0.3
Other	NA	0.7	NA	0.9	1.0	1.1	1.2	1.0	0.9	1.3	1.0	0.9	1.5	1.1	0.7	0.7	0.7	0.8	0.8	0.8

(continued)

Appendix table 2-5.
Selected characteristics of American college freshmen: 1971-90
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	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Freshmen planning to major in non-science/engineering fields																			
	Percent																			
Average grade in high school																				
A or A+	7.0	8.6	9.3	8.7	9.5	10.5	10.3	12.3	10.7	10.1	10.6	10.7	10.9	10.8	10.4	11.8	11.4	12.5	12.4	11.3
A-	11.5	14.5	11.8	13.5	13.7	14.5	13.4	15.9	14.1	14.2	13.4	13.6	12.4	12.1	13.2	13.4	13.1	13.7	15.2	14.8
B+	20.4	22.2	23.8	21.9	22.5	23.9	23.1	23.1	20.8	21.8	21.1	21.8	21.0	20.0	21.5	20.2	21.3	20.8	20.4	20.6
B	25.9	26.9	28.4	28.3	26.6	27.2	27.0	24.9	26.4	27.1	26.8	26.6	25.1	25.5	25.0	25.5	23.4	23.5	25.7	25.3
B-	16.0	12.5	13.4	12.6	13.4	11.8	11.8	11.6	12.5	11.6	13.6	13.0	13.5	13.6	12.6	13.7	15.7	14.0	13.1	13.4
C+	12.1	10.0	7.6	9.3	9.0	7.9	8.8	8.1	9.8	9.8	9.5	9.6	11.3	11.5	11.3	10.2	8.2	9.9	8.7	10.0
C	6.9	5.1	5.5	5.3	5.3	4.1	5.3	4.0	5.4	5.1	4.8	4.6	5.6	6.2	5.8	5.0	6.6	5.4	4.3	4.5
D	0.2	0.3	0.1	0.3	0.1	0.1	0.3	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1
Father's education																				
Grammar school or less	7.2	6.3	5.4	5.9	5.4	5.7	5.7	5.0	4.6	4.9	4.3	4.4	4.1	4.6	3.6	2.9	2.5	2.8	2.4	3.5
Some high school	13.4	12.7	10.4	10.9	11.4	10.8	9.9	9.1	9.9	9.2	8.5	8.2	8.5	7.9	7.6	6.7	5.4	5.7	5.6	5.5
High school graduate	28.1	27.5	26.3	26.4	26.5	26.0	27.9	25.6	25.7	25.9	26.5	25.6	25.2	25.8	23.7	23.6	24.1	23.7	23.7	24.7
Postsecondary (not college)	NA	NA	4.8	4.5	4.6	4.2	4.1	4.2	3.7	4.3	3.6	4.1	4.1	4.6	4.4	4.6	4.5	4.5	5.0	4.9
Some college	17.9	17.4	15.9	15.5	13.8	14.1	14.1	14.9	14.0	14.0	14.6	13.7	15.0	13.9	14.8	15.3	14.2	15.3	14.9	15.7
College degree	21.2	19.5	20.4	20.2	20.4	21.4	20.6	22.5	22.9	21.6	22.3	22.7	22.0	22.6	22.5	22.6	23.6	23.2	23.9	23.1
Some graduate school	NA	3.1	2.5	2.4	2.6	2.8	2.5	2.6	2.8	3.1	2.8	2.6	2.8	2.5	3.2	3.1	3.4	3.2	3.1	2.6
Graduate degree	12.1	13.6	14.3	14.1	15.3	15.1	15.1	16.1	16.3	17.1	17.4	18.6	18.3	18.1	20.2	21.2	22.3	21.5	21.5	20.0
Mother's education																				
Grammar school or less	4.0	3.7	3.0	3.5	3.1	3.3	3.2	3.1	2.7	3.0	2.5	2.5	2.2	2.3	2.2	1.9	1.9	2.3	1.7	2.5
Some high school	11.2	10.4	8.4	9.2	8.5	8.8	8.8	8.2	8.5	7.1	6.4	6.7	6.9	6.1	6.4	5.0	4.2	4.3	4.2	4.2
High school graduate	43.5	41.9	39.7	39.1	40.2	38.9	40.7	39.5	38.6	38.9	39.1	38.2	36.5	36.6	33.2	32.0	31.4	31.1	30.3	30.9
Postsecondary (not college)	NA	NA	8.1	8.1	7.1	8.1	7.4	7.0	7.4	6.9	7.1	6.8	7.4	8.2	7.2	8.0	8.3	7.8	7.9	7.8
Some college	19.7	20.1	16.4	16.2	16.1	15.6	15.2	15.8	15.8	17.2	16.9	16.4	17.4	16.1	18.1	18.6	18.2	18.2	18.3	18.1
College degree	18.0	16.4	17.2	16.8	17.1	17.9	16.8	17.6	17.8	18.0	18.5	19.2	18.9	19.4	20.7	21.2	21.7	21.7	22.7	22.4
Some graduate school	NA	2.5	2.6	2.4	2.3	2.1	2.2	2.5	2.7	2.4	2.4	2.6	2.5	2.7	3.3	3.3	3.4	3.5	3.7	3.2
Graduate degree	3.6	4.9	4.5	4.7	5.5	5.3	5.6	6.3	6.5	6.4	7.1	7.6	8.1	8.5	8.9	10.1	11.0	11.2	11.2	11.0
Father's occupation																				
Artist (including performer)	0.8	0.8	NA	NA	NA	1.0	0.7	0.9	0.9	1.0	0.9	1.0	1.1	1.0	1.0	0.8	1.0	1.0	1.0	0.8
Businessman	33.0	33.2	NA	NA	NA	33.0	32.5	33.5	34.0	32.9	33.3	33.4	33.2	31.6	32.8	35.0	34.6	33.3	32.6	30.1
Clergy or religious worker	1.2	1.2	NA	NA	NA	1.5	1.3	1.5	1.3	1.4	1.4	1.1	1.0	1.0	1.0	1.3	0.9	1.0	1.1	1.4
College teacher	1.0	1.1	NA	NA	NA	1.1	1.2	1.1	0.9	1.0	1.2	1.1	1.1	1.0	1.3	1.0	1.2	1.2	1.0	0.9
Doctor or dentist	2.5	2.7	NA	NA	NA	3.1	2.6	3.1	2.7	3.0	2.8	3.2	3.0	2.8	2.8	3.2	3.1	3.1	3.0	2.8
Education (secondary)	2.7	2.8	NA	NA	NA	3.3	2.9	3.0	3.8	3.3	3.5	3.5	3.8	3.8	4.0	3.8	4.2	4.2	4.2	4.2
Education (elementary)	0.4	0.5	NA	NA	NA	0.5	0.6	0.8	0.5	0.6	0.6	0.7	0.7	0.8	0.7	0.9	0.8	1.0	1.0	1.1
Engineer	7.0	7.4	NA	NA	NA	7.9	8.0	8.6	8.0	7.7	8.1	7.4	7.4	7.9	8.1	7.4	7.6	7.2	7.5	7.1
Farmer or forester	5.7	5.2	NA	NA	NA	4.8	3.9	3.5	3.4	3.8	4.7	4.2	3.7	4.1	4.6	2.9	2.9	2.9	2.9	3.3
Health professional (non-MD)	1.5	1.5	NA	NA	NA	1.1	1.3	1.8	1.4	1.3	1.3	1.4	1.4	1.3	1.3	1.3	1.4	1.5	1.1	1.1

(continued)

Appendix table 2-5.

Selected characteristics of American college freshmen: 1971-90

(page 5 of 7)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Freshmen planning to major in non-science/engineering fields																				
Percent																				
Lawyer	1.5	1.7	NA	NA	NA	2.0	1.7	1.8	1.7	1.9	2.0	2.2	2.2	2.0	2.1	2.3	2.5	2.3	2.4	2.1
Military (career)	1.9	1.8	NA	NA	NA	2.0	1.9	1.8	1.6	1.7	1.8	1.7	2.2	1.3	1.3	2.0	1.6	1.5	1.8	1.7
Research scientist	0.8	0.7	NA	NA	NA	0.6	0.6	0.7	0.7	0.6	0.7	0.6	0.7	0.5	0.6	0.6	0.7	0.7	0.5	0.5
Skilled worker	10.9	10.6	NA	NA	NA	8.9	9.6	8.7	9.4	9.9	9.0	9.0	8.8	9.2	7.6	7.7	7.9	9.0	8.7	9.0
Semi-skilled worker	6.6	5.5	NA	NA	NA	5.0	5.3	4.3	4.9	4.5	4.0	3.8	4.2	4.2	3.9	3.3	3.2	3.1	3.3	3.7
Laborer (unskilled)	3.1	3.6	NA	NA	NA	3.3	3.2	2.8	3.0	2.9	2.5	2.9	2.9	2.6	3.1	2.3	2.3	2.6	2.7	2.7
Unemployed	1.1	1.8	NA	NA	NA	1.9	2.0	2.1	1.9	2.2	1.7	2.0	2.7	2.3	2.4	2.3	1.9	1.9	2.0	2.3
Other	18.4	17.9	NA	NA	NA	19.1	20.6	20.3	20.0	20.3	20.5	20.9	20.0	22.6	21.6	21.9	22.2	22.3	23.1	25.3
Mother's occupation																				
Artist (including performer)	0.9	0.9	NA	NA	NA	1.3	1.3	1.4	1.3	1.4	1.6	1.7	1.8	1.3	1.8	1.8	1.8	2.0	1.8	1.6
Businesswoman	4.6	5.5	NA	NA	NA	6.2	7.4	7.4	8.1	8.6	10.5	9.7	10.7	11.7	13.5	14.7	14.8	14.4	13.9	14.4
Business (clerical)	9.4	11.0	NA	NA	NA	9.9	10.7	10.4	10.8	11.5	11.5	11.4	11.6	11.9	11.3	11.3	12.1	10.8	11.0	10.0
Clergy or religious worker	0.0	0.1	NA	NA	NA	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
College teacher	0.5	0.4	NA	NA	NA	0.4	0.4	0.3	0.3	0.4	0.5	0.4	0.4	0.5	0.4	0.3	0.4	0.5	0.5	0.6
Doctor or dentist	0.1	0.2	NA	NA	NA	0.1	0.2	0.2	0.1	0.2	0.2	0.3	0.2	0.3	0.4	0.6	0.4	0.6	0.4	0.6
Education (secondary)	2.5	3.2	NA	NA	NA	3.0	2.7	3.0	3.2	3.1	3.7	4.1	3.2	3.8	3.8	4.3	4.4	4.5	4.8	4.6
Education (elementary)	4.8	5.4	NA	NA	NA	6.1	6.0	6.5	6.3	5.8	6.1	6.7	6.0	6.2	6.5	6.9	7.8	8.0	8.2	7.9
Engineer	0.1	0.0	NA	NA	NA	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Farmer or forester	0.1	0.2	NA	NA	NA	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.2	0.3	0.4	0.1	0.3	0.3	0.3	0.3
Health professional (non-MD)	1.2	1.2	NA	NA	NA	1.6	1.5	1.4	1.5	1.8	1.6	1.7	2.2	1.8	2.0	1.8	1.7	2.0	2.4	2.2
Homemaker (full-time)	53.0	36.6	NA	NA	NA	36.5	32.7	33.0	30.0	28.4	24.6	23.0	24.9	24.0	22.0	19.6	18.0	17.4	15.9	15.5
Lawyer	0.0	0.1	NA	NA	NA	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.4	0.2	0.3	0.3	0.4	0.4
Nurse	4.1	4.9	NA	NA	NA	6.2	6.0	6.4	6.5	6.7	7.3	7.1	7.8	8.1	7.9	7.0	6.8	7.2	7.6	8.0
Research scientist	0.0	0.0	NA	NA	NA	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Social/welfare worker	0.7	0.9	NA	NA	NA	0.9	1.2	1.0	1.2	1.0	1.4	1.3	1.1	1.3	1.3	1.4	1.5	1.4	1.4	1.4
Skilled worker	1.2	1.6	NA	NA	NA	1.3	1.5	1.6	1.6	1.7	1.5	1.8	1.9	1.8	1.6	1.7	2.1	1.9	2.2	1.8
Semi-skilled worker	2.4	2.5	NA	NA	NA	2.7	3.0	2.7	2.7	3.2	2.7	3.0	2.9	2.5	[illegible]	2.0	2.2	2.1	2.3	2.7
Laborer (unskilled)	1.5	1.8	NA	NA	NA	1.9	1.9	1.8	2.1	2.2	1.8	2.0	1.8	1.6	[illegible]	1.5	1.4	1.8	1.5	1.6
Unemployed	2.9	10.5	NA	NA	NA	8.5	7.8	7.8	8.3	7.7	7.8	8.0	6.3	5.9	5.7	6.2	5.5	5.3	5.3	5.2
Other	10.0	13.1	NA	NA	NA	12.8	15.3	14.6	15.5	15.8	16.6	17.0	16.3	16.4	16.8	17.8	18.2	19.2	19.7	20.8
Student's probable career																				
Accountant or actuary	4.1	3.7	NA	NA	NA	7.8	8.5	8.5	7.9	8.6	8.3	8.2	8.2	9.3	9.6	7.9	7.9	7.9	8.0	7.1
Architect	1.6	1.7	NA	NA	NA	1.5	1.6	1.9	1.6	1.6	1.0	1.1	1.0	1.3	1.2	1.4	1.3	1.5	1.8	1.6
Business (management)	5.7	5.9	NA	NA	NA	9.8	11.3	12.3	13.2	13.3	14.4	14.1	15.4	16.8	16.9	17.8	17.7	16.9	15.8	13.5
Clinical psychologist	0.1	0.1	NA	NA	NA	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2
College teacher	0.9	0.8	NA	NA	NA	0.6	0.5	0.4	0.3	0.3	0.2	0.3	0.4	0.4	0.3	0.4	0.4	0.4	0.6	0.4
Computer programmer	0.4	0.4	NA	NA	NA	1.0	1.3	1.6	2.1	3.1	3.6	4.8	4.7	3.1	2.5	1.7	1.1	1.2	1.0	1.0
Conservationist or forester	1.8	1.6	NA	NA	NA	1.0	1.4	0.9	0.6	0.6	0.8	0.4	0.3	0.2	0.3	0.2	0.2	0.3	0.3	0.4
Engineer	0.4	0.2	NA	NA	NA	0.4	0.5	0.3	0.5	0.7	0.6	0.7	0.6	0.4	0.4	0.3	0.4	0.4	0.4	0.5

(continued)

Appendix table 2-5.

Selected characteristics of American college freshmen: 1971-90

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	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Freshmen planning to major in non-science/engineering fields																				
	Percent																			
Farmer or rancher	1.0	0.8	NA	NA	NA	0.9	1.0	0.7	0.9	0.7	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.4	0.4	0.4
Foreign service worker	0.6	0.5	NA	NA	NA	0.6	0.4	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.6	0.6	0.6
Lawyer	5.8	6.6	NA	NA	NA	4.6	4.7	4.1	4.7	4.6	4.4	5.1	4.6	4.4	3.9	4.1	4.6	5.2	5.6	5.0
Military service (career)	1.0	1.2	NA	NA	NA	0.5	0.6	0.7	0.6	0.5	0.6	0.6	0.6	0.7	0.5	0.8	0.7	0.6	0.5	0.4
Nurse	4.6	4.6	NA	NA	NA	5.9	4.8	5.2	4.7	5.1	4.7	5.6	5.5	4.5	3.7	3.0	2.3	2.6	2.4	3.6
Physician	6.1	6.8	NA	NA	NA	3.2	4.3	4.7	4.4	4.7	4.6	4.9	4.9	4.9	5.0	4.5	3.7	4.1	4.2	4.6
School counselor	0.1	0.2	NA	NA	NA	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2
Scientific researcher	0.5	0.5	NA	NA	NA	0.3	0.3	0.4	0.2	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Social worker	0.7	0.4	NA	NA	NA	0.9	0.7	0.7	0.7	0.5	0.3	0.3	0.4	0.3	0.2	0.3	0.3	0.3	0.3	0.2
Statistician	0.0	0.0	NA	NA	NA	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.1
Therapist (e.g., physical)	2.6	3.4	NA	NA	NA	3.8	3.7	3.6	3.2	3.3	3.5	3.5	3.3	3.9	2.8	2.9	3.0	3.2	3.2	3.5
Teacher (elementary)	10.2	8.6	NA	NA	NA	7.8	6.9	6.1	6.6	6.1	6.5	4.6	5.3	5.4	5.2	5.9	6.9	6.4	6.3	7.9
Teacher (secondary)	10.9	8.3	NA	NA	NA	5.9	4.5	4.4	3.9	3.7	3.1	2.7	3.1	2.8	3.5	3.9	4.2	4.3	4.3	4.8
Veterinarian	1.3	2.1	NA	NA	NA	1.2	1.3	1.5	1.2	1.4	1.1	0.9	1.0	0.8	1.1	1.0	0.8	0.7	0.8	0.7
Writer or journalist	2.4	2.7	NA	NA	NA	3.4	3.2	3.4	4.0	3.6	4.0	3.7	3.7	3.6	4.3	3.9	3.7	4.0	4.1	3.8
Skilled trades	0.5	0.4	NA	NA	NA	0.3	1.3	0.6	0.5	0.6	0.6	0.4	0.5	0.3	0.3	0.3	0.2	0.6	0.5	0.4
Other	5.4	5.0	NA	NA	NA	5.4	5.1	5.4	6.1	6.0	5.9	5.2	5.4	4.8	4.9	5.3	5.5	5.4	6.8	7.9
Undecided	12.9	14.4	NA	NA	NA	11.9	11.7	12.4	12.4	12.4	12.1	13.3	12.8	13.5	12.9	14.4	14.2	13.5	13.8	13.6
Student's probable major																				
Agriculture	3.1	3.0	3.2	4.0	3.9	3.4	3.1	2.5	2.4	2.2	2.7	2.1	1.6	1.4	1.3	1.1	0.9	1.0	1.2	1.3
Business	15.9	14.8	19.9	21.6	22.2	24.0	26.6	29.5	29.8	30.0	32.2	31.9	32.2	36.6	35.9	36.0	36.3	34.6	34.1	30.7
Education	15.3	11.9	20.1	17.7	16.7	16.3	14.3	13.2	13.3	11.9	11.0	9.1	10.6	9.7	9.3	11.4	12.3	11.6	11.7	14.0
English	4.5	2.9	3.3	2.2	2.2	2.0	1.8	2.1	1.7	1.7	1.7	1.5	1.9	1.7	2.1	2.3	2.1	2.3	2.6	2.7
Health professional	17.8	19.9	8.7	10.8	10.2	10.9	15.1	15.5	14.3	15.4	14.4	15.5	15.4	15.2	13.8	12.2	10.6	11.6	12.4	13.8
History or political science	3.8	3.4	2.8	2.1	1.8	1.8	1.5	1.1	1.3	1.0	[illegible]	1.1	1.2	1.4	1.3	1.4	1.4	1.5	1.7	1.8
Humanities	5.1	5.6	4.7	4.8	3.7	3.6	2.8	2.5	2.5	2.2	2.4	2.3	2.2	2.2	2.4	2.5	2.6	2.7	2.4	2.6
Fine arts	11.2	10.8	10.3	11.0	10.1	9.5	9.5	9.4	8.7	8.8	8.6	8.0	7.5	7.1	7.2	8.0	8.4	7.3	8.0	7.3
Other technical	4.0	4.5	7.3	6.7	7.4	6.7	5.4	4.6	5.2	6.6	6.4	7.3	7.2	4.6	4.1	3.3	2.9	3.8	2.5	2.5
Other nontechnical	15.9	15.8	12.6	12.1	13.8	14.4	12.0	12.2	13.0	12.0	11.1	12.3	11.5	11.0	12.7	11.3	11.7	12.8	12.3	12.7
Undecided	3.3	7.4	7.0	7.0	8.1	7.5	8.0	7.3	8.0	8.1	8.4	8.8	8.7	9.1	10.0	10.6	10.8	10.7	11.1	10.6

(continued)

Appendix table 2-5.

Selected characteristics of American college freshmen: 1971-90

(page 7 of 7)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Freshmen planning to major in non-science/engineering fields																			
	Percent																			
Highest degree planned																				
None	NA	1.5	NA	2.2	2.8	2.2	1.6	1.5	1.2	1.3	1.5	1.5	2.5	1.7	2.3	1.8	1.7	2.0	0.9	1.3
Associate or equivalent	NA	1.4	NA	2.2	1.6	1.7	2.2	1.6	2.1	2.1	1.9	2.0	1.3	1.6	1.0	0.9	0.8	1.5	0.9	0.8
Bachelors	NA	41.5	NA	44.0	41.6	40.4	39.4	40.0	39.3	40.7	40.1	39.5	37.6	39.5	38.7	37.7	37.4	31.8	32.5	30.4
Masters	NA	28.8	NA	30.9	32.3	32.9	33.4	33.9	34.7	33.0	35.1	33.6	35.1	34.5	36.1	38.4	39.3	41.2	41.8	42.1
Doctorate	NA	7.4	NA	7.1	7.3	8.0	7.7	7.6	7.1	7.0	7.6	7.9	7.6	8.4	7.5	8.0	8.6	10.1	9.8	10.8
Professional (e.g., MD, DDS)	NA	10.7	NA	6.6	6.0	6.3	7.8	8.2	7.7	8.0	7.4	7.9	7.5	7.3	8.1	7.1	6.0	6.1	6.6	7.1
Law	NA	6.6	NA	4.1	5.3	5.3	5.1	5.0	5.1	4.9	4.7	5.3	5.2	4.8	3.8	4.1	4.4	5.2	5.4	5.1
Divinity	NA	0.6	NA	0.7	0.5	0.5	0.6	0.5	0.6	0.4	0.3	0.4	0.5	0.4	0.5	0.2	0.3	0.4	0.4	0.5
Other	NA	1.5	NA	2.2	2.6	2.5	2.3	1.7	2.2	2.6	1.3	1.8	2.6	1.8	2.0	1.7	1.5	1.7	1.6	1.9

NA = data not collected

SOURCE: Higher Education Research Institute, University of California at Los Angeles, unpublished tabulations.

See figures 2-2 and 2-3.

Science & Engineering Indicators – 1991

Appendix table 2-6.

Undergraduate enrollment in engineering and engineering technology programs: 1979-89

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Engineering programs											
Total enrollment	366,299	397,344	420,402	435,330	441,205	429,499	420,864	407,657	392,198	385,412	378,277
Total full time	340,488	365,117	387,577	403,390	406,144	394,635	384,191	369,520	356,998	346,169	338,529
Freshman	103,724	110,149	115,280	115,303	109,638	105,249	103,225	99,238	95,453	98,009	95,420
Sophomore	78,594	84,982	87,519	89,785	89,515	83,946	79,627	76,195	73,317	71,030	71,267
Junior	74,926	80,024	86,633	90,541	91,233	89,509	84,875	80,386	77,085	73,761	70,483
Senior	77,823	84,442	92,414	102,055	109,036	109,695	110,305	107,773	104,003	97,614	94,465
Fifth year	5,419	5,520	5,731	5,706	6,722	6,236	6,159	5,928	7,140	5,755	6,894
Total part time	25,811	32,227	32,825	31,940	35,061	34,864	36,673	38,137	35,200	39,243	39,748
Total number of schools	286	287	286	286	292	289	297	311	316	320	323
ABET-accredited schools[1]	239	246	250	249	258	258	264	270	277	281	284
Engineering technology programs											
Total enrollment	NA	NA	191,152	176,133	163,226	157,897	123,571	137,390	128,501	131,704	127,687
Total full time	NA	NA	134,444	120,342	112,745	111,446	83,038	90,536	80,600	79,624	76,179
First year	NA	NA	65,893	59,339	53,032	46,806	34,389	39,177	32,685	33,477	32,225
Second year	NA	NA	40,774	36,807	33,799	31,716	23,293	25,612	22,906	21,852	21,627
Other full-time associates	NA	NA	872	797	925	1,165	466	657	1,404	1,760	1,810
Bachelor of engineering technology third and later years	NA	NA	26,905	23,399	24,989	31,759	24,890	25,090	23,605	22,535	20,517
Total part time	NA	NA	56,708	55,791	50,481	46,451	40,533	46,854	47,901	52,080	51,508
Number of schools	NA	NA	NA	NA	NA	NA	200	257	291	310	286

NA = not available

[1] Schools with at least one curriculum accredited by the Accreditation Board of Engineering and Technology (ABET).

SOURCE: Engineering Manpower Commission, American Association of Engineering Societies, *Engineering & Technology Enrollments, Fall 1989, Parts I and II* (Washington, DC: AAES, 1990).

See figure 2-4.

Science & Engineering Indicators – 1991

Appendix table 2-7.
Bachelors degree conferrals, by field and gender: 1980-89

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					Total					
Total, all baccalaureates	940,251	946,877	964,043	980,679	986,345	990,880	1,000,352	1,003,532	1,006,033	1,030,171
Total science and engineering	291,983	294,867	302,118	307,229	314,666	321,739	323,950	318,942	308,760	307,580
Total sciences	232,743	230,799	234,327	234,275	238,135	243,868	246,889	244,237	238,354	240,366
Physical sciences	17,506	17,481	17,311	16,199	15,834	16,271	15,786	15,466	14,263	14,148
Mathematics	11,473	11,173	11,708	12,557	13,342	15,267	16,388	16,626	16,122	15,439
Computer sciences	11,213	15,233	20,431	24,682	32,435	39,121	42,195	39,927	34,896	30,963
Environmental sciences	6,155	6,694	7,061	7,298	7,925	7,576	6,076	4,689	3,554	3,181
Life sciences	71,617	68,086	65,041	63,237	59,613	57,812	56,465	56,215	54,280	52,612
Psychology	42,513	41,364	41,539	40,825	40,375	40,237	40,937	43,195	45,378	48,954
Social sciences	72,266	70,768	71,236	69,477	68,611	67,584	69,042	68,119	69,861	75,069
Total engineering	59,240	64,068	67,791	72,954	76,531	77,871	77,061	74,705	70,406	67,214
					Men					
Total, all baccalaureates	477,750	474,336	477,543	483,395	486,750	486,662	490,306	485,003	481,236	487,566
Total science and engineering	186,009	186,425	188,957	191,617	196,650	200,301	200,893	194,633	186,671	183,787
Total sciences	132,783	129,474	129,503	128,382	130,952	133,746	135,035	131,401	127,105	126,817
Physical sciences	13,317	13,167	12,779	11,586	11,177	11,434	11,090	10,793	9,677	9,777
Mathematics	6,625	6,392	6,650	7,059	7,428	8,231	8,772	8,900	8,662	8,333
Computer sciences	7,814	10,280	13,316	15,690	20,369	24,690	27,069	26,038	23,543	21,418
Environmental sciences	4,693	5,028	5,254	5,450	5,991	5,715	4,722	2,629	2,707	2,380
Life sciences	44,021	40,610	38,115	36,677	34,253	32,664	31,643	31,592	29,731	28,787
Psychology	15,590	14,447	13,756	13,228	12,949	12,815	12,691	13,399	13,584	14,291
Social sciences	40,723	39,550	39,633	38,692	38,785	38,197	39,048	38,050	39,201	41,831
Total engineering	53,226	56,951	59,454	63,235	65,698	66,555	65,858	63,232	59,566	56,970
					Women					
Total, all baccalaureates	462,501	472,541	486,500	497,284	499,595	504,218	510,046	518,529	524,797	542,604
Total science and engineering	105,974	108,442	113,161	115,612	118,016	121,438	123,057	123,309	122,089	123,793
Total sciences	99,960	101,325	104,824	105,893	107,183	110,122	111,854	111,836	111,249	113,549
Physical sciences	4,189	4,314	4,532	4,613	4,657	4,837	4,696	4,673	4,586	4,371
Mathematics	4,848	4,781	5,058	5,498	5,914	7,036	7,616	7,726	7,460	7,106
Computer sciences	3,399	4,953	7,115	8,992	12,066	14,431	15,126	13,889	11,353	9,545
Environmental sciences	1,462	1,666	1,807	1,848	1,934	1,861	1,354	1,060	847	801
Life sciences	27,596	27,476	26,926	26,560	25,360	25,148	24,822	24,623	24,549	23,825
Psychology	26,923	26,917	27,783	27,597	27,426	27,422	28,246	29,796	31,794	34,663
Social sciences	31,543	31,218	31,603	30,785	29,826	29,387	29,994	30,069	30,660	33,238
Total engineering	6,014	7,117	8,337	9,719	10,833	11,316	11,203	11,473	10,840	10,244

SOURCE: Science Resources Studies Division, National Science Foundation, *Science and Engineering Degrees: 1966-89, A Source Book*, NSF 91-314, Detailed Statistical Tables (Washington, DC: NSF, 1991).

See figure 2-5 and figure O-15 in Overview.

Science & Engineering Indicators – 1991

Appendix table 2-8.

Bachelors degree conferrals, by field and racial/ethnic group: 1977-89

(page 1 of 2)

Field[1]	1977	1979	1981	1985	1987	1989
Total, U.S. citizens and permanent residents						
Total science and engineering	326,418	322,195	322,189	345,400	339,934	336,582
Total sciences	280,325	264,192	253,803	257,992	254,800	257,857
Physical sciences[2]	22,038	22,659	23,441	22,892	19,027	16,482
Mathematics	13,977	11,534	10,717	14,212	15,506	14,524
Computer sciences	6,161	8,392	14,455	36,692	35,943	27,721
Life sciences[3]	74,230	71,442	64,560	55,479	51,729	48,561
Psychology	47,297	42,561	40,878	39,406	41,248	47,396
Social sciences[4]	116,622	107,604	99,752	89,311	91,347	103,173
Total engineering[5]	46,093	58,003	68,386	87,408	85,134	78,725
White, non-Hispanic						
Total science and engineering	290,175	284,852	281,924	299,662	289,700	283,260
Total sciences	248,103	232,201	221,068	223,357	217,834	218,035
Physical sciences[2]	20,417	20,958	21,249	20,541	16,653	14,238
Mathematics	12,602	10,229	9,447	12,163	13,265	12,287
Computer sciences	5,508	7,404	12,566	31,321	29,181	21,711
Life sciences[3]	67,891	64,445	57,529	48,248	44,034	40,594
Psychology	41,494	36,648	34,718	33,959	35,761	40,506
Social sciences[4]	100,191	92,517	85,559	77,125	78,940	88,699
Total engineering[5]	42,072	52,651	60,856	76,305	71,866	65,225
Black, non-Hispanic						
Total science and engineering	19,455	18,743	18,828	18,075	18,279	18,405
Total sciences	18,070	16,968	16,379	14,933	14,859	15,251
Physical sciences[2]	692	704	911	830	823	697
Mathematics	712	652	585	770	834	792
Computer sciences	361	507	786	2,143	2,820	2,457
Life sciences[3]	2,724	2,837	2,650	2,417	2,185	2,225
Psychology	3,221	3,218	3,308	2,667	2,451	2,743
Social sciences[4]	10,360	9,050	8,139	6,106	5,746	6,337
Total engineering[5]	1,385	1,775	2,449	3,142	3,420	3,154
Asian						
Total science and engineering	6,096	7,080	9,027	13,791	17,612	19,734
Total sciences	4,885	5,222	5,961	8,784	11,234	12,831
Physical sciences[2]	377	439	599	763	894	922
Mathematics	316	324	392	885	1,034	1,019
Computer sciences	163	263	669	2,044	2,455	2,268
Life sciences[3]	1,558	1,788	1,807	2,197	2,844	3,146
Psychology	807	781	843	845	1,154	1,575
Social sciences[4]	1,664	1,627	1,651	2,050	2,853	3,901
Total engineering[5]	1,211	1,858	3,066	5,007	6,378	6,903

(continued)

Appendix table 2-8.
Bachelors degree conferrals, by field and racial/ethnic group: 1977-89
(page 2 of 2)

Field[1]	1977	1979	1981	1985	1987	1989
Native American						
Total science & engineering	1,155	1,187	1,202	1,484	1,350	1,323
Total sciences	1,020	1,023	1,007	1,175	1,067	1,048
Physical sciences[2]	68	63	65	98	72	62
Mathematics	26	41	18	59	52	53
Computer sciences	15	11	21	139	112	90
Life sciences[3]	270	233	233	231	202	215
Psychology	167	177	196	201	180	420
Social sciences[4]	474	498	474	447	449	208
Total engineering[5]	135	164	195	309	283	275
Hispanic						
Total science & engineering	9,537	10,333	11,208	12,388	12,993	13,860
Total sciences	8,247	8,778	9,388	9,743	9,806	10,692
Physical sciences[2]	484	495	617	660	585	563
Mathematics	321	288	275	335	321	373
Computer sciences	114	207	413	1,045	1,375	1,195
Life sciences[3]	1,787	2,139	2,341	2,386	2,464	2,381
Psychology	1,608	1,737	1,813	1,734	1,702	2,152
Social sciences[4]	3,933	3,912	3,929	3,583	3,359	4,028
Total engineering[5]	1,290	1,555	1,820	2,645	3,187	3,168

NOTES: Data by racial/ethnic group are collected on a biennial schedule; data are provided by institutions; imputations are done for some nonresponse. Racial/ethnic categories are designated on the survey form. These categories include U.S. citizens and foreign citizens on permanent visas. Data are not available by racial/ethnic group for foreign citizens on temporary visas.

[1] Data on racial/ethnic groups are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[2] Includes environmental sciences.

[3] Excludes health sciences.

[4] For 1977 to 1981, social sciences included Afro-American black cultural studies and American Indian studies.

[5] Includes engineering technology. Racial/ethnic data for engineering and engineering technology can only be separated for 1985 and 1987.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations from the Completion Survey conducted by the National Center for Education Statistics.

Science & Engineering Indicators – 1991

Appendix table 2-9.

Freshman intentions as predictor of science and engineering bachelors degrees

	Engineering	Computer sciences	Natural sciences	Social & behavioral sciences
	Freshman intentions[1]			
	Percent			
1977	9.5	0.9	11.8	9.5
1978	10.1	1.5	11.6	9.4
1979	10.5	1.8	10.1	9.0
1980	11.4	2.5	9.2	8.3
1981	11.1	3.8	9.4	7.7
1982	12.0	4.9	8.7	7.2
1983	11.5	4.9	9.1	7.6
1984	11.0	3.5	9.1	8.6
1985	10.5	2.5	8.5	9.0
1986	10.2	1.9	8.2	9.5
1987	9.5	1.6	7.7	10.0
1988	8.9	1.6	7.8	11.3
1989	9.8	1.6	8.2	11.0
1990	9.7	1.7	8.4	11.0
	Share of bachelors degrees[2]			
1980	6.3	1.2	11.4	12.2
1981	6.8	1.6	10.9	11.8
1982	7.0	2.1	10.5	11.7
1983	7.4	2.5	10.1	11.2
1984	7.8	3.3	9.8	11.0
1985	7.9	3.9	9.8	10.9
1986	7.7	4.2	9.5	11.0
1987	7.4	4.0	9.3	11.1
1988	7.0	3.5	8.8	11.5
1989	6.5	3.0	8.3	12.6

[1] Percentage of freshmen at 4-year colleges and universities who plan to major in a science or engineering field.

[2] Science and engineering bachelors degrees as a pecentage of all bachelors degrees.

SOURCES: Science Resources Studies Division, National Science Foundation, unpublished tabulations; and Higher Education Research Institute, University of California at Los Angeles, unpublished tabulations.

See figure 2-6.

Science & Engineering Indicators – 1991

Appendix table 2-10.
Science and engineering graduate students, by field and gender: 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
						Total					
Total science & engineering	327,533	334,059	340,707	349,547	352,027	360,722	370,487	375,632	378,274	386,047	401,569
Total sciences	252,449	253,580	256,126	257,610	258,383	263,771	267,416	270,988	274,555	281,232	292,270
Physical sciences	26,952	27,382	28,199	29,466	30,064	30,995	32,260	32,738	32,972	33,628	34,337
Mathematics	15,360	15,915	17,199	17,397	17,478	17,613	17,990	18,573	19,141	19,382	19,884
Computer sciences	13,578	16,437	19,812	23,616	25,810	29,844	31,425	32,137	32,787	32,846	34,507
Environmental sciences	14,208	14,422	15,174	15,544	15,612	15,545	15,163	14,522	14,032	13,848	14,159
Life sciences	60,144	59,079	58,624	58,345	58,233	57,918	58,545	58,456	59,316	60,655	62,104
Psychology	40,636	40,691	40,082	41,039	41,074	41,308	41,551	42,888	44,389	46,304	48,659
Social sciences	81,571	79,654	77,036	72,203	70,112	70,548	70,482	71,674	71,918	74,569	78,620
Total engineering	75,084	80,479	84,581	91,937	93,644	96,951	103,071	104,644	103,719	104,815	109,299
						Men					
Total science & engineering	232,753	233,604	236,602	242,234	243,683	249,089	255,324	257,686	256,113	258,889	266,292
Total sciences	164,172	161,056	160,987	160,276	160,574	163,470	164,922	166,131	165,719	167,874	171,954
Physical sciences	22,352	22,366	22,776	23,586	23,904	24,483	25,395	25,620	25,473	25,825	26,223
Mathematics	11,272	11,419	12,109	12,184	12,295	12,227	12,501	12,944	13,348	13,359	13,646
Computer sciences	10,491	12,228	14,366	16,968	18,905	22,387	23,677	24,233	24,564	24,880	26,316
Environmental sciences	10,940	10,945	11,393	11,593	11,694	11,571	11,183	10,708	10,164	9,923	9,994
Life sciences	38,939	37,580	36,335	35,755	35,473	34,904	34,965	34,776	34,695	35,013	35,367
Psychology	19,036	17,902	16,977	16,687	16,216	15,778	15,459	15,744	15,643	15,906	15,963
Social sciences	51,142	48,616	47,031	43,503	42,087	42,120	41,742	42,106	41,832	42,968	44,445
Total engineering	68,581	72,548	75,615	81,958	83,109	85,619	90,402	91,555	90,394	91,015	94,338
						Women					
Total science & engineering	94,780	100,455	104,105	107,313	108,344	111,633	115,163	117,946	122,161	127,158	135,277
Total sciences	88,277	92,524	95,139	97,334	97,809	100,301	102,494	104,857	108,836	113,358	120,316
Physical sciences	4,600	5,016	5,423	5,880	6,160	6,512	6,865	7,118	7,499	7,803	8,114
Mathematics	4,088	4,496	5,090	5,213	5,183	5,386	5,489	5,629	5,793	6,023	6,238
Computer sciences	3,087	4,209	5,446	6,648	6,905	7,457	7,748	7,904	8,223	7,966	8,191
Environmental sciences	3,268	3,477	3,781	3,951	3,918	3,974	3,980	3,814	3,868	3,925	4,165
Life sciences	21,205	21,499	22,289	22,590	22,760	23,014	23,580	23,680	24,621	25,642	26,737
Psychology	21,600	22,789	23,105	24,352	24,858	25,530	26,092	27,144	28,746	30,398	32,696
Social sciences	30,429	31,038	30,005	28,700	28,025	28,428	28,740	29,568	30,086	31,601	34,175
Total engineering	6,503	7,931	8,966	9,979	10,535	11,332	12,669	13,089	13,325	13,800	14,961

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington, DC: NSF, 1991), unpublished tabulations; and annual series.

See figure 2-7.

Science & Engineering Indicators – 1991

Appendix table 2-11.

Science and engineering graduate students, by field and racial/ethnic group: 1983-90

(page 1 of 2)

	1983	1984	1985	1986	1987	1988	1989	1990
Total, U.S. citizens[1]								
Total science & engineering	278,994	279,554	283,741	286,279	287,606	284,243	287,681	299,110
Total sciences	214,676	213,916	215,725	215,349	216,457	215,893	219,731	227,938
Physical sciences	21,805	22,017	22,054	22,232	22,110	21,860	21,820	21,826
Mathematics	12,442	12,285	12,262	12,179	12,443	12,716	12,711	13,443
Computer sciences	18,068	19,451	22,386	23,419	23,409	23,717	23,122	23,778
Environmental sciences	13,679	13,808	13,651	13,067	12,299	11,589	11,247	11,442
Life sciences	49,567	49,208	48,366	47,918	47,785	46,612	46,878	47,391
Psychology	39,605	39,685	39,811	40,047	41,346	42,726	44,652	46,819
Social sciences	59,510	57,462	57,195	56,487	57,065	56,673	59,301	63,239
Total engineering	64,318	65,638	68,016	70,930	71,149	68,350	67,950	71,172
White								
Total science & engineering	226,010	224,118	224,898	228,655	230,170	230,855	232,012	241,210
Total sciences	176,909	174,289	174,063	175,249	175,991	178,030	180,165	186,869
Physical sciences	18,657	18,595	18,338	18,565	18,098	18,292	18,328	18,570
Mathematics	10,293	9,976	9,818	9,547	9,695	10,188	10,174	10,705
Computer sciences	13,482	13,983	15,569	16,498	17,149	17,660	16,665	17,436
Environmental sciences	12,322	12,021	11,860	11,654	11,035	10,531	10,309	10,476
Life sciences	43,665	43,725	42,051	41,767	40,532	40,454	40,107	40,343
Psychology	32,665	32,143	32,741	33,285	34,872	36,120	37,815	39,511
Social sciences	45,825	43,846	43,686	43,933	44,610	44,785	46,767	49,828
Total engineering	49,101	49,829	50,835	53,406	54,179	52,825	51,847	54,341
Black								
Total science & engineering	11,045	10,781	10,587	10,580	10,510	11,246	11,779	12,891
Total sciences	9,634	9,306	9,165	9,071	9,075	9,713	10,131	11,081
Physical sciences	575	596	535	524	536	569	633	653
Mathematics	404	394	410	450	442	422	463	512
Computer sciences	564	561	609	686	750	825	838	984
Environmental sciences	111	108	122	98	95	108	96	125
Life sciences	1,296	1,295	1,332	1,238	1,194	1,304	1,372	1,441
Psychology	1,911	1,933	1,815	1,815	1,825	1,983	2,094	2,289
Social sciences	4,773	4,419	4,342	4,260	4,233	4,502	4,635	5,077
Total engineering	1,411	1,475	1,422	1,509	1,435	1,533	1,648	1,810
Asian								
Total science & engineering	9,393	10,208	12,049	12,883	14,639	15,256	15,778	17,474
Total sciences	5,974	6,374	7,222	7,697	8,754	9,289	9,745	10,699
Physical sciences	748	891	937	912	1,047	1,213	1,141	1,217
Mathematics	564	565	625	707	771	759	710	900
Computer sciences	1,099	1,251	1,853	2,078	2,463	2,690	2,748	2,864
Environmental sciences	239	187	193	152	181	210	211	267
Life sciences	1,409	1,460	1,602	1,716	1,846	2,035	2,263	2,585
Psychology	532	545	559	619	728	752	821	964
Social sciences	1,383	1,475	1,453	1,513	1,718	1,630	1,851	1,902
Total engineering	3,419	3,834	4,827	5,186	5,885	5,967	6,033	6,775

(continued)

Appendix table 2-11.
Science and engineering graduate students, by field and racial/ethnic group: 1983-90
(page 2 of 2)

	1983	1984	1985	1986	1987	1988	1989	1990
				Native American				
Total science & engineering . .	919	835	741	752	788	928	859	1,048
Total sciences.	738	643	619	620	664	784	734	891
Physical sciences.	45	77	35	48	46	52	44	63
Mathematics	32	23	22	32	48	32	34	20
Computer sciences	22	48	56	20	27	40	41	42
Environmental sciences . .	27	23	23	21	19	29	27	30
Life sciences	153	108	109	130	118	139	110	157
Psychology	136	116	136	135	153	179	181	236
Social sciences	323	248	238	234	253	313	297	343
Total engineering.	181	192	122	132	124	144	125	157
				Hispanic				
Total science & engineering . .	8,928	8,715	8,637	8,713	8,842	9,132	9,487	10,502
Total sciences.	7,463	7,193	7,140	7,071	7,108	7,401	7,762	8,547
Physical sciences.	563	535	599	629	591	624	680	641
Mathematics	331	292	262	270	266	328	305	370
Computer sciences	282	292	481	445	544	517	546	566
Environmental sciences . .	226	263	241	239	228	211	213	241
Life sciences	1,138	1,103	1,263	1,265	1,262	1,405	1,510	1,530
Psychology	1,814	1,903	1,613	1,709	1,669	1,728	1,756	2,159
Social sciences	3,109	2,805	2,681	2,514	2,548	2,588	2,752	3,040
Total engineering.	1,465	1,522	1,497	1,642	1,734	1,731	1,725	1,955

NOTE: Data on racial/ethnic groups are only available for U.S. citizens.

[1] Total includes racial/ethnic group unknown.

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington, DC: NSF, 1991), unpublished tabulations; and annual series.

See figure 2-8.

Appendix table 2-12.
First year full-time science and engineering graduate enrollment, by field and gender: 1982-90

	1982	1983	1984	1985	1986	1987	1988	1989	1990
					Total				
Total science & engineering	70,351	72,405	70,829	71,771	73,618	71,508	71,484	75,506	76,934
Total sciences	51,969	53,140	51,666	53,335	53,029	52,006	52,145	55,566	56,681
Physical sciences	6,185	6,705	6,513	6,645	6,935	6,779	6,528	6,842	6,817
Mathematics	3,694	3,600	3,738	3,985	4,029	3,900	3,919	4,224	4,244
Computer sciences	3,330	3,898	4,056	4,774	5,033	5,135	5,229	5,707	5,396
Environmental sciences	3,648	3,775	3,387	3,275	3,091	2,609	2,603	2,672	2,707
Life sciences	12,540	12,700	12,528	12,305	12,172	12,037	12,011	12,416	12,770
Psychology	7,567	7,804	7,558	7,837	7,703	7,874	8,258	9,115	8,800
Social sciences	15,005	14,658	13,886	14,514	14,066	13,672	13,597	14,590	15,947
Total engineering	18,382	19,265	19,163	18,436	20,589	19,502	19,339	19,940	20,253
					Men				
Total science & engineering	48,019	49,403	48,399	48,324	49,782	48,049	47,207	49,345	49,710
Total sciences	31,909	32,504	31,604	32,306	31,930	31,202	30,644	32,286	32,497
Physical sciences	4,747	5,144	5,025	5,099	5,280	5,145	4,812	5,039	5,011
Mathematics	2,582	2,458	2,622	2,732	2,777	2,623	2,637	2,773	2,821
Computer sciences	2,450	2,894	2,992	3,620	3,874	3,941	3,967	4,426	4,208
Environmental sciences	2,650	2,753	2,482	2,364	2,245	1,854	1,804	1,825	1,863
Life sciences	7,363	7,448	7,325	7,076	6,819	6,714	6,646	6,810	6,853
Psychology	2,961	3,001	2,849	2,899	2,700	2,858	2,747	2,965	2,791
Social sciences	9,156	8,806	8,309	8,516	8,235	8,067	8,031	8,448	8,950
Total engineering	16,110	16,899	16,795	16,018	17,852	16,847	16,563	17,059	17,213
					Women				
Total science & engineering	22,332	23,002	22,430	23,447	23,836	23,459	24,277	26,161	27,224
Total sciences	20,060	20,636	20,062	21,029	21,099	20,804	21,501	23,280	24,184
Physical sciences	1,438	1,561	1,488	1,546	1,655	1,634	1,716	1,803	1,806
Mathematics	1,112	1,142	1,116	1,253	1,252	1,277	1,282	1,451	1,423
Computer sciences	880	1,004	1,064	1,154	1,159	1,194	1,262	1,281	1,188
Environmental sciences	998	1,022	905	911	846	755	799	847	844
Life sciences	5,177	5,252	5,203	5,229	5,353	5,323	5,365	5,606	5,917
Psychology	4,606	4,803	4,709	4,938	5,003	5,016	5,511	6,150	6,009
Social sciences	5,849	5,852	5,577	5,998	5,831	5,605	5,566	6,142	6,997
Total engineering	2,272	2,366	2,368	2,418	2,737	2,655	2,776	2,881	3,040

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington, DC: NSF, 1991), unpublished tabulations; and annual series.

Appendix table 2-13.

Part-time science and engineering graduate enrollment, by field and gender: 1982-90

	1982	1983	1984	1985	1986	1987	1988	1989	1990
				Total					
Total science & engineering	117,937	118,977	119,845	125,129	126,063	126,980	125,631	126,636	133,948
Total sciences	83,589	81,361	81,729	84,461	83,700	84,503	85,312	86,537	91,196
Physical sciences	4,159	4,261	4,212	4,326	4,496	4,324	4,398	4,435	4,764
Mathematics	6,376	6,433	6,159	5,780	5,592	5,524	5,618	5,677	6,014
Computer sciences	10,641	12,929	14,223	15,743	16,115	16,565	17,191	16,838	17,635
Environmental sciences	3,738	3,495	3,793	4,106	3,840	3,979	3,736	3,710	3,864
Life sciences	11,744	11,397	11,003	11,459	11,138	10,684	10,558	10,745	11,458
Psychology	14,270	14,338	14,966	15,539	15,030	15,391	15,909	16,132	17,667
Social sciences	32,661	28,508	27,373	27,508	27,489	28,036	27,902	29,000	29,794
Total engineering	34,348	37,616	38,116	40,668	42,363	42,477	40,319	40,099	42,752
				Men					
Total science & engineering	79,676	80,012	80,587	83,927	84,443	84,648	82,464	82,489	86,292
Total sciences	48,887	46,621	46,821	48,176	47,608	47,900	47,750	47,944	49,680
Physical sciences	3,135	3,215	3,149	3,242	3,372	3,236	3,265	3,290	3,495
Mathematics	4,080	4,140	3,963	3,612	3,503	3,453	3,540	3,590	3,819
Computer sciences	7,506	8,930	10,080	11,336	11,702	11,988	12,367	12,174	12,944
Environmental sciences	2,785	2,555	2,765	2,997	2,793	2,882	2,658	2,576	2,649
Life sciences	6,564	6,196	6,004	6,141	5,886	5,711	5,383	5,431	5,774
Psychology	5,696	5,282	5,460	5,422	5,127	5,260	5,328	5,237	5,206
Social sciences	19,121	16,303	15,400	15,426	15,225	15,370	15,209	15,646	15,793
Total engineering	30,789	33,391	33,766	35,751	36,835	36,748	34,714	34,545	36,612
				Women					
Total science & engineering	38,261	38,965	39,258	41,202	41,620	42,332	43,167	44,147	47,656
Total sciences	34,702	34,740	34,908	36,285	36,092	36,603	37,562	38,593	41,516
Physical sciences	1,024	1,046	1,063	1,084	1,124	1,088	1,133	1,145	1,269
Mathematics	2,296	2,293	2,196	2,168	2,089	2,071	2,078	2,087	2,195
Computer sciences	3,135	3,999	4,143	4,407	4,413	4,577	4,824	4,664	4,691
Environmental sciences	953	940	1,028	1,109	1,047	1,097	1,078	1,134	1,215
Life sciences	5,180	5,201	4,999	5,318	5,252	4,973	5,175	5,314	5,684
Psychology	8,574	9,056	9,506	10,117	9,903	10,131	10,581	10,895	12,461
Social sciences	13,540	12,205	11,973	12,082	12,264	12,666	12,693	13,354	14,001
Total engineering	3,559	4,225	4,350	4,917	5,528	5,729	5,605	5,554	6,140

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington, DC: NSF, 1991), unpublished tabulations; and annual series.

Appendix table 2-14.

Masters degree conferrals, by field and gender: 1980-89

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					Total					
Total, all masters degrees	299,095	296,798	296,580	290,931	285,462	287,210	289,823	290,532	300,091	311,050
Total science and engineering	54,391	54,811	57,025	58,868	59,569	61,278	62,526	63,018	63,897	66,026
Total sciences	37,545	37,438	38,431	39,147	39,217	40,072	41,212	40,737	41,006	42,098
Physical sciences	3,440	3,424	3,514	3,329	3,586	3,642	3,676	3,587	3,730	3,876
Mathematics	2,868	2,569	2,731	2,839	2,749	2,888	3,171	3,327	3,434	3,431
Computer sciences	3,647	4,218	4,935	5,321	6,190	7,101	8,070	8,481	9,166	9,399
Environmental sciences	1,793	1,876	2,012	1,959	1,982	2,160	2,234	2,051	1,920	1,819
Life sciences	10,278	9,731	9,824	9,720	9,330	8,757	8,572	8,831	8,559	8,430
Psychology	7,861	8,039	7,849	8,439	8,073	8,481	8,363	8,165	7,925	8,652
Social sciences	7,658	7,581	7,566	7,540	7,307	7,043	7,126	6,295	6,272	6,491
Total engineering	16,846	17,373	18,594	19,721	20,352	21,206	21,314	22,281	22,891	23,928
					Men					
Total, all masters degrees	151,159	147,431	145,941	145,114	143,998	143,717	143,932	141,655	145,403	149,399
Total science and engineering	40,008	39,797	41,049	41,787	41,894	42,979	43,344	43,480	44,416	45,262
Total sciences	24,352	23,830	24,139	23,942	23,701	24,101	24,501	24,040	24,379	24,466
Physical sciences	2,801	2,743	2,765	2,636	2,736	2,811	2,759	2,694	2,838	2,836
Mathematics	1,832	1,692	1,821	1,859	1,795	1,877	2,055	2,026	2,057	2,061
Computer sciences	2,883	3,247	3,625	3,813	4,379	5,064	5,658	5,985	6,702	6,773
Environmental sciences	1,457	1,470	1,560	1,515	1,517	1,639	1,717	1,531	1,433	1,337
Life sciences	6,952	6,451	6,315	6,111	5,728	5,265	5,022	5,180	5,011	4,849
Psychology	3,397	3,371	3,228	3,254	2,980	3,064	2,937	2,838	2,599	2,814
Social sciences	5,030	4,856	4,825	4,754	4,566	4,381	4,353	3,786	3,739	3,796
Total engineering	15,656	15,967	16,910	17,845	18,193	18,878	18,843	19,440	20,037	20,796
					Women					
Total, all masters degrees	147,936	149,367	150,639	145,817	141,464	143,493	145,891	148,877	154,688	161,651
Total science and engineering	14,383	15,014	15,976	17,081	17,675	18,299	19,182	19,538	19,481	20,764
Total sciences	13,193	13,608	14,292	15,205	15,516	15,971	16,711	16,697	16,627	17,632
Physical sciences	639	681	749	693	850	831	917	893	892	1,040
Mathematics	1,036	877	910	980	954	1,011	1,116	1,301	1,377	1,370
Computer sciences	764	971	1,310	1,508	1,811	2,037	2,412	2,496	2,464	2,626
Environmental sciences	336	406	452	444	465	521	517	520	487	482
Life sciences	3,326	3,280	3,509	3,609	3,602	3,492	3,550	3,651	3,548	3,581
Psychology	4,464	4,668	4,621	5,185	5,093	5,417	5,426	5,327	5,326	5,838
Social sciences	2,628	2,725	2,741	2,786	2,741	2,662	2,773	2,509	2,533	2,695
Total engineering	1,190	1,406	1,684	1,876	2,159	2,328	2,471	2,841	2,854	3,132

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990,* NSF 91-320 (Washington, DC: NSF, 1991), unpublished tabulations; and annual series.

See figure 2-9.

Appendix table 2-15.
Masters degree conferrals, by field and racial/ethnic group: 1977-89
(page 1 of 2)

Field[1]	1977	1979	1981	1985	1987	1989
Total, U.S. citizens and permanent residents						
Total science & engineering	55,054	50,201	48,711	50,994	50,720	51,872
Total sciences	42,359	38,784	36,909	36,094	34,773	35,510
Physical sciences[2]	4,689	4,713	4,457	4,563	4,271	4,232
Mathematics	3,328	2,571	2,103	2,146	2,331	2,309
Computer sciences	2,432	2,528	3,239	5,233	5,848	6,061
Life sciences[3]	9,748	9,697	8,954	7,624	6,963	6,561
Psychology	8,149	7,852	7,769	8,129	7,493	7,994
Social sciences[4]	14,013	11,423	10,387	8,399	7,867	8,353
Total engineering[5]	12,695	11,417	11,802	14,900	15,947	16,362
White, non-Hispanic						
Total science & engineering	49,670	45,185	43,435	44,387	43,715	44,316
Total sciences	38,226	35,103	33,288	31,808	30,476	30,894
Physical sciences[2]	4,363	4,373	4,115	4,133	3,834	3,766
Mathematics	3,048	2,352	1,890	1,873	2,012	2,032
Computer sciences	2,208	2,273	2,818	4,303	4,717	4,786
Life sciences[3]	9,042	8,909	8,296	6,946	6,236	5,878
Psychology	7,201	7,078	7,019	7,220	6,698	7,075
Social sciences[4]	12,364	10,118	9,150	7,333	6,979	7,357
Total engineering[5]	11,444	10,082	10,147	12,579	13,239	13,422
Black, non-Hispanic						
Total science & engineering	2,266	1,988	1,787	1,755	1,803	1,688
Total sciences	2,026	1,742	1,527	1,396	1,370	1,287
Physical sciences[2]	94	86	107	89	79	78
Mathematics	133	71	67	53	73	59
Computer sciences	67	65	70	180	207	198
Life sciences[3]	257	296	244	226	245	177
Psychology	506	476	424	426	376	395
Social sciences[4]	969	748	615	422	390	380
Total engineering[5]	240	246	260	359	433	401
Asian						
Total science & engineering	1,693	1,895	2,132	3,276	3,475	4,100
Total sciences	956	1,045	1,053	1,703	1,783	2,073
Physical sciences[2]	142	160	153	213	227	278
Mathematics	90	104	97	164	183	178
Computer sciences	108	149	279	615	779	894
Life sciences[3]	246	309	212	254	247	276
Psychology	95	87	77	129	113	131
Social sciences[4]	275	236	235	328	234	316
Total engineering[5]	737	850	1,079	1,573	1,692	2,027

(continued)

Appendix table 2-15.
Masters degree conferrals, by field and racial/ethnic group: 1977-89
(page 2 of 2)

Field[1]	1977	1979	1981	1985	1987	1989
			Native American			
Total science & engineering	148	163	159	222	171	205
Total sciences	125	139	128	173	108	170
Physical sciences[2]	21	29	11	21	9	18
Mathematics	12	8	7	7	3	6
Computer sciences	3	16	12	41	22	39
Life sciences[3]	27	21	22	24	17	23
Psychology	26	20	32	37	35	33
Social sciences[4]	36	45	44	43	22	51
Total engineering[5]	23	24	31	49	63	35
			Hispanic			
Total science & engineering	1,277	970	1,198	1,354	1,556	1,563
Total sciences	1,026	755	913	1,014	1,036	1,086
Physical sciences[2]	69	65	71	107	122	92
Mathematics	45	36	42	49	60	34
Computer sciences	46	25	60	94	123	144
Life sciences[3]	176	162	180	174	218	207
Psychology	321	191	217	317	271	360
Social sciences[4]	369	276	343	273	242	249
Total engineering[5]	251	215	285	340	520	477

NOTES: Data by racial/ethnic group are collected on a biennial schedule; data are provided by institutions; imputations are done for some nonresponse. Racial/ethnic categories are designated on the survey form. These categories include U.S. citizens and foreign citizens on permanent visas. Data are not available by racial/ethnic group for foreign citizens on temporary visas.

[1] Data on racial/ethnic groups are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[2] Includes environmental sciences.

[3] Excludes health sciences.

[4] For 1977 to 1981, social sciences included Afro-American black cultural studies and American Indian studies.

[5] Includes engineering technology. Racial/ethnic data for engineering and engineering technology can only be separated for 1985 and 1987.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations from the Completion Survey conducted by the National Center for Education Statistics.

Appendix table 2-16.
Doctorate conferrals, by field and gender: 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total											
Total, all doctorates	31,020	31,357	31,111	31,282	31,337	31,297	31,895	32,364	33,490	34,319	36,027
Total science & engineering	17,523	17,996	18,017	18,393	18,514	18,712	19,251	19,707	20,741	21,530	22,673
Total sciences	15,044	15,468	15,371	15,612	15,601	15,546	15,875	15,995	16,551	16,986	17,781
Physical sciences	2,521	2,627	2,694	2,802	2,845	2,916	3,090	3,212	3,317	3,244	3,494
Mathematics	744	728	720	701	698	688	729	740	749	859	892
Computer sciences	218	232	220	286	295	310	399	450	515	612	704
Environmental sciences	628	583	657	637	614	617	589	628	728	740	769
Life sciences	4,715	4,786	4,844	4,756	4,877	4,904	4,805	4,816	5,127	5,203	5,509
Psychology	3,098	3,358	3,159	3,347	3,257	3,117	3,124	3,169	3,064	3,203	3,267
Social sciences	3,120	3,154	3,077	3,083	3,015	2,994	3,139	2,980	3,051	3,125	3,146
Total engineering	2,479	2,528	2,646	2,781	2,913	3,166	3,376	3,712	4,190	4,544	4,892
Men											
Total, all doctorates	21,612	21,465	21,018	20,749	20,638	20,553	20,591	20,938	21,679	21,811	22,966
Total science & engineering	13,639	13,880	13,747	13,769	13,810	13,900	14,167	14,472	15,164	15,522	16,399
Total sciences	11,250	11,451	11,225	11,112	11,048	10,932	11,016	11,002	11,260	11,353	11,921
Physical sciences	2,199	2,318	2,337	2,431	2,446	2,452	2,585	2,686	2,760	2,627	2,843
Mathematics	649	616	624	588	583	582	608	615	628	704	734
Computer sciences	197	206	200	250	258	277	351	385	459	504	594
Environmental sciences	564	527	554	540	508	506	489	514	583	590	620
Life sciences	3,565	3,565	3,552	3,390	3,529	3,495	3,353	3,284	3,436	3,433	3,657
Psychology	1,787	1,885	1,721	1,750	1,626	1,576	1,526	1,474	1,388	1,406	1,361
Social sciences	2,289	2,334	2,237	2,163	2,098	2,044	2,104	2,044	2,006	2,089	2,112
Total engineering	2,389	2,429	2,522	2,657	2,762	2,968	3,151	3,470	3,904	4,169	4,478
Women											
Total, all doctorates	9,408	9,892	10,093	10,533	10,699	10,744	11,304	11,426	11,811	12,508	13,061
Total science & engineering	3,884	4,116	4,270	4,624	4,704	4,812	5,084	5,235	5,577	6,008	6,274
Total sciences	3,794	4,017	4,146	4,500	4,553	4,614	4,859	4,993	5,291	5,633	5,860
Physical sciences	322	309	357	371	399	464	505	526	557	617	651
Mathematics	95	112	96	113	115	106	121	125	121	155	158
Computer sciences	21	26	20	36	37	33	48	65	56	108	110
Environmental sciences	64	56	103	97	106	111	100	114	145	150	149
Life sciences	1,150	1,221	1,292	1,366	1,348	1,409	1,452	1,532	1,691	1,770	1,852
Psychology	1,311	1,473	1,438	1,597	1,631	1,541	1,598	1,695	1,676	1,797	1,906
Social sciences	831	820	840	920	917	950	1,035	936	1,045	1,036	1,034
Total engineering	90	99	124	124	151	198	225	242	286	375	414

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Science and Engineering Doctorate Awards: 1990*. NSF 91-310 (Washington, DC.: NSF, 1991).

See figure 2-9.

Appendix table 2-17.
Doctorate conferrals, by field and racial/ethnic group: 1980-90
(page 1 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TOTAL, ALL DOCTORATES	26,512	26,342	25,619	25,634	25,251	24,694	24,513	24,561	24,911	25,024	25,844
White	22,462	22,470	22,143	22,245	21,864	21,297	21,224	21,116	21,455	21,568	22,345
Black	1,105	1,110	1,143	1,005	1,055	1,043	949	907	966	962	972
Asian	1,102	1,073	1,004	1,043	1,019	1,069	1,058	1,167	1,236	1,260	1,260
Native American	75	85	77	82	74	96	99	115	94	94	93
Hispanic	485	526	614	608	607	634	678	709	696	694	813
TOTAL SCIENCE AND ENGINEERING	14,362	14,437	14,146	14,301	14,085	13,876	13,856	13,906	14,346	14,432	14,776
White	12,146	12,388	12,330	12,478	12,246	12,004	12,014	11,921	12,326	12,364	12,727
Black	319	332	336	322	357	357	318	308	346	352	340
Asian	866	821	765	778	774	808	807	921	913	979	968
Native American	27	26	38	28	31	41	52	52	41	52	40
Hispanic	213	238	269	282	295	290	342	354	394	379	451
Total sciences	12,808	12,966	12,681	12,819	12,572	12,282	12,130	11,993	12,198	12,203	12,473
White	11,003	11,295	11,230	11,350	11,089	10,816	10,660	10,463	10,672	10,638	10,909
Black	301	313	316	293	342	323	294	283	315	319	300
Asian	588	536	519	531	524	527	545	594	580	619	623
Native American	24	22	35	27	28	40	46	45	37	45	36
Hispanic	186	222	233	253	261	268	307	320	331	331	398
Physical sciences	2,035	2,103	2,110	2,184	2,190	2,178	2,147	2,227	2,236	2,119	2,244
White	1,661	1,757	1,859	1,917	1,888	1,900	1,858	1,942	1,927	1,817	1,929
Black	16	24	26	25	34	27	25	20	33	31	27
Asian	164	149	131	136	144	150	146	143	137	155	161
Native American	3	1	3	6	4	3	5	7	6	10	3
Hispanic	27	30	25	26	47	30	40	56	63	59	70
Mathematics	582	525	499	457	443	418	402	396	386	428	416
White	496	448	437	395	380	350	343	319	332	369	367
Black	12	9	6	3	4	7	6	11	4	8	4
Asian	42	40	32	34	30	33	28	41	33	24	25
Native American	0	1	1	0	3	0	1	0	2	0	1
Hispanic	5	5	6	7	11	12	12	11	4	11	10
Computer sciences	169	188	155	207	195	213	249	275	326	396	396
White	143	162	136	174	163	177	193	229	265	319	334
Black	0	2	1	3	3	3	1	2	2	1	1
Asian	9	16	12	20	20	17	37	26	44	52	46
Native American	0	0	1	1	0	0	0	3	1	2	0
Hispanic	1	0	1	0	3	6	7	4	2	4	5
Environmental sciences	538	488	557	513	499	474	446	450	542	559	544
White	485	448	510	453	461	430	413	408	500	509	502
Black	1	4	3	1	3	4	1	2	3	4	2
Asian	22	14	27	26	19	21	14	18	15	23	17
Native American	2	0	0	2	0	1	2	0	2	6	1
Hispanic	4	6	7	11	2	6	5	5	8	9	13
Life sciences	4,035	4,050	4,104	4,009	4,059	3,982	3,868	3,774	3,933	3,951	3,967
White	3,511	3,566	3,678	3,608	3,646	3,572	3,445	3,313	3,484	3,475	3,505
Black	58	61	56	58	68	69	64	73	68	70	56
Asian	198	181	182	197	178	175	189	208	201	222	223
Native American	6	7	10	5	11	17	17	13	12	9	7
Hispanic	36	56	54	49	52	71	83	77	97	90	111

(continued)

Appendix table 2-17.

Doctorate conferrals, by field and racial/ethnic group: 1980-90

(page 2 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Psychology	2,909	3,158	2,923	3,108	2,986	2,864	2,831	2,806	2,728	2,738	2,859
White	2,562	2,849	2,638	2,783	2,683	2,590	2,547	2,516	2,445	2,453	2,551
Black	119	113	115	112	121	105	109	93	103	97	110
Asian	50	41	31	44	43	44	41	47	47	55	51
Native American	6	9	16	9	6	10	9	16	7	11	18
Hispanic	54	66	74	94	84	69	89	95	93	93	103
Social sciences	2,540	2,454	2,333	2,341	2,200	2,153	2,187	2,065	2,047	2,012	2,047
White	2,145	2,065	1,972	2,020	1,868	1,797	1,861	1,736	1,719	1,696	1,721
Black	95	100	109	91	109	108	88	82	102	108	100
Asian	103	95	104	74	90	87	90	111	103	88	100
Native American	7	4	4	4	4	9	12	6	7	7	6
Hispanic	59	59	66	66	62	74	71	72	64	65	86
Total engineering	1,554	1,471	1,465	1,482	1,513	1,594	1,726	1,913	2,148	2,229	2,303
White	1,143	1,093	1,100	1,128	1,157	1,188	1,354	1,458	1,654	1,726	1,818
Black	18	19	20	29	15	34	24	25	31	33	40
Asian	278	285	246	247	250	281	262	327	333	360	345
Native American	3	4	3	1	3	1	6	7	4	7	4
Hispanic	27	16	36	29	34	22	35	34	63	48	53

NOTE: Data are for U.S. citizens and permanent residents only.

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Science and Engineering Doctorate Awards: 1990*, NSF 91-310 (Washington, DC.: NSF, 1991).

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Appendix table 2-18.

Time to degree from U.S. baccalaureate to science and engineering doctorate: 1974-89

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Chemistry Ph.D.s	1,451	1,438	1,307	1,266	1,219	1,280	1,192	1,282	1,337	1,408	1,372	1,399	1,378	1,430	1,455	1,377
Total time to degree	7.12	7.12	7.20	7.13	7.22	6.92	6.94	6.94	6.92	7.28	7.24	7.21	7.46	7.39	7.41	7.42
Enrolled time to degree	5.98	5.94	6.06	6.03	6.06	5.91	5.97	5.98	6.00	6.18	6.23	6.33	6.27	6.22	6.27	6.32
Physics and astronomy Ph.D.s	999	970	946	872	825	848	757	743	728	749	770	734	745	768	806	751
Total time to degree	8.16	8.20	8.19	8.42	8.31	7.93	8.32	8.04	8.33	8.23	8.18	8.35	8.52	8.44	8.31	8.40
Enrolled time to degree	6.93	7.03	7.01	7.11	7.17	6.93	7.16	7.08	7.28	7.23	7.16	7.28	7.20	7.25	7.24	7.24
Math/computer science Ph.D.s	897	865	766	742	722	734	690	663	623	622	587	576	588	621	653	752
Total time to degree	8.33	8.03	8.27	8.15	8.57	8.51	8.49	8.50	8.47	9.29	9.30	9.51	9.42	9.84	10.40	10.51
Enrolled time to degree	6.57	6.45	6.51	6.69	6.75	6.86	6.85	7.01	7.03	7.42	7.14	7.41	7.34	7.49	7.56	7.54
Environmental science Ph.D.s	473	496	512	567	521	540	522	472	525	485	483	443	417	426	507	534
Total time to degree	9.52	9.58	8.84	9.39	8.97	8.86	9.48	9.64	9.59	9.77	9.96	9.91	10.27	10.66	10.68	10.63
Enrolled time to degree	6.80	6.82	6.64	7.00	6.89	6.97	7.11	7.29	7.24	7.64	7.78	7.66	7.85	7.87	8.08	7.94
Life science Ph.D.s	3,350	3,568	3,594	3,531	3,614	3,768	3,949	4,011	4,090	3,928	4,003	3,919	3,808	3,683	3,869	3,847
Total time to degree	8.31	8.29	8.40	8.33	8.29	8.33	8.28	8.34	8.54	8.81	9.06	9.14	9.37	9.48	9.62	9.90
Enrolled time to degree	6.39	6.44	6.47	6.45	6.51	6.51	6.62	6.72	6.87	6.89	7.11	7.12	7.16	7.31	7.38	7.44
Psychology Ph.D.s	2,406	2,589	2,732	2,773	2,842	2,873	2,875	3,133	2,904	3,074	2,946	2,872	2,789	2,798	2,781	2,638
Total time to degree	8.82	8.86	8.78	9.03	9.17	9.49	9.72	10.11	10.45	10.62	11.03	11.24	11.42	11.72	12.01	12.17
Enrolled time to degree	6.44	6.48	6.54	6.62	6.78	6.96	7.12	7.24	7.47	7.58	7.86	7.93	7.96	8.10	8.25	8.44
Economics Ph.D.s	739	769	731	694	669	649	628	674	587	616	555	577	593	520	540	546
Total time to degree	8.78	8.93	9.22	9.01	9.31	9.37	9.44	9.22	9.38	9.69	9.72	10.04	9.95	10.04	10.01	10.30
Enrolled time to degree	6.40	6.52	6.47	6.72	6.66	6.82	6.88	7.00	7.08	7.16	7.35	7.61	7.37	7.64	7.56	7.55
Political science Ph.D.s	770	749	670	604	603	511	482	445	439	448	441	431	420	403	395	413
Total time to degree	10.65	11.14	10.21	10.83	10.77	11.06	10.84	11.15	11.98	12.07	11.71	12.51	12.97	12.86	13.10	12.34
Enrolled time to degree	6.96	7.22	7.31	7.65	7.55	7.80	7.78	7.89	8.26	8.34	8.23	8.84	9.04	8.64	8.92	8.83
Other social science Ph.D.s	1,309	1,374	1,418	1,362	1,278	1,231	1,231	1,203	1,152	1,135	1,061	1,024	1,028	965	955	864
Total time to degree	10.43	10.28	10.64	10.69	10.85	11.30	11.22	11.40	11.72	12.18	12.59	13.09	13.27	13.55	14.05	14.10
Enrolled time to degree	7.22	7.05	7.32	7.61	7.63	8.06	7.99	8.27	8.52	8.81	9.06	9.30	9.32	9.54	9.80	9.73

SOURCE: Policy Research and Analysis Division, National Science Foundation, unpublished tabulations from Survey of Earned Doctorates.

See figure 2-10.

Science & Engineering Indicators – 1991

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Appendix table 2-19.

Ratio of doctorates to bachelors awards, lagged by time to degree

	Year of doctorate														
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Percent														
Chemistry	13.7	11.5	11.1	11.0	12.2	11.9	12.4	12.7	13.1	12.4	12.5	12.1	12.6	12.9	12.3
Physics and astronomy	16.5	15.4	13.3	12.5	12.7	12.1	12.1	12.2	13.8	14.4	13.3	13.3	13.7	13.7	12.7
Math and computer sciences	4.8	3.9	3.2	3.0	3.1	3.0	2.9	2.8	2.8	2.9	3.1	3.3	3.6	3.9	4.5
Environmental sciences	NA	NA	NA	NA	18.3	17.3	14.5	14.4	12.4	11.5	10.4	9.6	9.3	10.1	10.1
Life sciences	11.5	10.7	9.4	8.7	8.6	8.7	8.1	7.5	6.6	6.4	5.9	5.7	5.5	5.9	6.0
Psychology	19.7	17.6	15.4	13.1	12.0	10.8	11.0	9.3	9.0	8.1	7.4	7.1	7.2	7.3	7.2
Economics	6.9	6.0	4.7	4.2	3.9	3.9	4.5	4.0	4.3	4.0	4.2	4.1	3.4	3.4	3.4
Political science	NA	NA	4.5	3.8	2.9	2.3	2.0	2.0	1.9	1.8	1.7	1.6	1.6	1.6	1.8
Other social sciences[1]	NA	NA	9.5	7.8	6.7	5.4	4.6	4.0	3.7	3.3	3.1	3.1	2.9	2.8	2.8
Engineering	5.0	4.6	4.3	3.4	3.2	3.1	2.8	2.8	3.0	3.5	3.7	3.8	3.6	3.8	3.5

NA = data not available

NOTE: See appendix table 2-18 for average time to degree by field.

[1] Other social sciences includes anthropology, sociology, history of science, linguistics, and other social science fields.

SOURCES: Policy Research and Analysis Division, National Science Foundation, unpublished tabulations from Survey of Earned Doctorate and from Completion Survey.

See figure 2-11.

Science & Engineering Indicators – 1991

Appendix table 2-20.
Full-time science and engineering graduate students, by field and source of support: 1980-90
(page 1 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TOTAL SCIENCE AND ENGINEERING	215,354	219,088	222,770	230,570	232,182	235,593	244,424	248,652	252,643	259,411	267,621
Federal	44,590	43,098	41,139	42,138	42,018	42,945	45,387	47,202	49,279	51,203	52,875
National Science Foundation	9,278	9,149	9,253	9,494	9,812	10,142	10,793	11,200	11,587	11,861	11,961
National Institutes of Health	10,614	10,132	9,583	9,673	9,972	10,083	10,770	11,491	12,377	12,993	13,416
Other Health & Human Svcs	2,148	1,802	1,412	1,114	947	1,164	1,106	1,157	999	1,179	1,250
Department of Defense	5,086	5,485	5,749	6,751	6,873	7,052	7,713	8,563	9,276	8,760	8,357
Other Federal	17,464	16,530	15,142	15,106	14,414	14,504	15,005	14,791	15,040	16,410	17,891
Non-Federal	104,440	109,282	113,486	116,847	120,409	123,923	129,066	130,819	133,663	137,465	141,158
Self-support	66,324	66,708	68,145	71,585	69,755	68,725	69,971	70,631	69,701	70,743	73,588
Total sciences	172,247	172,831	172,537	176,249	176,654	179,310	183,716	186,485	189,243	194,695	201,074
Federal	33,399	32,124	30,044	30,153	30,428	31,678	33,008	34,082	35,259	36,858	37,968
National Science Foundation	6,867	6,781	6,680	6,813	7,115	7,455	7,663	7,720	7,779	8,085	8,089
National Institutes of Health	10,106	9,686	9,180	9,196	9,506	9,628	10,321	10,976	11,822	12,349	12,742
Other Health & Human Svcs	1,991	1,699	1,310	1,016	869	1,095	1,019	1,043	926	1,094	1,128
Department of Defense	2,228	2,325	2,294	2,737	3,065	3,278	3,598	3,978	4,306	3,952	3,741
Other Federal	12,207	11,633	10,580	10,391	9,873	10,222	10,407	10,365	10,426	11,378	12,268
Non-Federal	85,278	87,764	90,066	92,181	94,150	95,717	98,421	99,614	101,951	104,600	107,416
Self-support	53,570	52,943	52,427	53,915	52,076	51,915	52,287	52,789	52,033	53,237	55,690
Physical sciences	22,918	23,308	24,040	25,205	25,852	26,669	27,764	28,414	28,574	29,193	29,573
Federal	7,707	7,956	7,713	8,126	8,640	8,821	9,523	9,717	9,857	10,247	10,333
National Science Foundation	2,887	3,036	3,114	3,218	3,406	3,516	3,671	3,590	3,656	3,612	3,576
National Institutes of Health	1,556	1,432	1,435	1,437	1,506	1,635	1,847	1,930	2,002	1,981	1,972
Other Health & Human Svcs	94	107	83	98	122	161	165	167	150	130	144
Department of Defense	661	753	707	831	1,011	1,024	1,161	1,292	1,475	1,392	1,216
Other Federal	2,509	2,628	2,374	2,542	2,595	2,485	2,679	2,738	2,574	3,132	3,425
Non-Federal	13,688	13,803	14,786	15,306	15,531	16,053	16,348	16,694	16,840	17,157	17,248
Self-support	1,523	1,549	1,541	1,773	1,681	1,795	1,893	2,003	1,877	1,789	1,992
Mathematics	9,902	10,154	10,823	10,964	11,319	11,833	12,398	13,049	13,523	13,705	13,870
Federal	868	796	818	760	762	935	999	1,090	1,190	1,211	1,346
National Science Foundation	262	227	228	223	279	321	357	436	463	475	500
National Institutes of Health	34	24	25	28	22	18	19	24	25	28	39
Other Health & Human Svcs	24	11	14	13	4	3	5	6	3	8	10
Department of Defense	329	343	374	310	304	386	432	438	513	395	367
Other Federal	219	191	177	186	153	207	186	186	186	305	430
Non-Federal	7,137	7,262	7,703	8,004	8,399	8,660	9,083	9,384	9,753	9,994	10,042
Self-support	1,897	2,096	2,302	2,200	2,158	2,238	2,316	2,575	2,580	2,500	2,482
Computer sciences	6,587	7,445	9,171	10,687	11,587	14,101	15,310	15,572	15,596	16,008	16,872
Federal	953	1,008	1,075	1,130	1,269	1,638	1,892	2,084	2,226	2,361	2,444
National Science Foundation	333	379	389	386	431	502	527	623	634	779	819
National Institutes of Health	66	48	42	26	24	20	43	61	64	53	62
Other Health & Human Svcs	6	2	5	3	1	1	2	1	0	7	9
Department of Defense	298	394	387	475	630	860	1,037	1,137	1,214	1,164	1,129
Other Federal	250	185	252	240	183	255	283	262	314	358	425
Non-Federal	2,696	3,050	3,523	4,050	4,509	5,686	6,127	6,283	6,462	6,602	6,893
Self-support	2,938	3,387	4,573	5,507	5,809	6,777	7,291	7,205	6,908	7,045	7,535
Environmental sciences	10,969	11,038	11,436	12,049	11,819	11,439	11,323	10,543	10,296	10,138	10,295
Federal	3,442	3,010	2,854	2,874	2,848	2,960	3,033	2,868	2,799	2,863	2,939
National Science Foundation	1,256	1,206	1,192	1,325	1,341	1,374	1,357	1,261	1,236	1,253	1,191
National Institutes of Health	34	20	42	15	30	26	25	24	19	17	21
Other Health & Human Svcs	87	79	35	23	11	15	14	34	32	8	13
Department of Defense	296	310	300	365	372	418	453	499	461	435	409
Other Federal	1,769	1,395	1,285	1,146	1,094	1,127	1,184	1,050	1,051	1,150	1,305
Non-Federal	4,912	5,231	5,474	5,554	5,640	5,561	5,566	5,232	5,379	5,357	5,251
Self-support	2,615	2,797	3,108	3,621	3,331	2,918	2,724	2,443	2,118	1,918	2,105

(continued)

Appendix table 2-20.

Full-time science and engineering graduate students, by field and source of support: 1980-90

(page 2 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Life sciences	47,908	47,658	46,880	46,948	47,230	46,459	47,407	47,772	48,758	49,910	50,646
Federal	12,743	12,489	11,941	11,914	11,890	12,324	12,867	13,658	14,337	15,162	15,533
National Science Foundation	1,296	1,226	1,203	1,132	1,151	1,171	1,155	1,200	1,175	1,306	1,282
National Institutes of Health	7,023	6,931	6,713	6,878	7,066	7,110	7,596	8,098	8,742	9,349	9,639
Other Health & Human Svcs	423	401	329	316	224	357	370	341	269	366	373
Department of Defense	173	133	131	258	258	248	209	281	320	275	260
Other Federal	3,828	3,798	3,565	3,330	3,191	3,438	3,537	3,738	3,831	3,866	3,979
Non-Federal	24,679	24,991	25,302	25,735	26,296	25,762	26,211	26,152	26,698	27,197	27,919
Self-support	10,486	10,178	9,637	9,299	9,044	8,373	8,329	7,962	7,723	7,551	7,194
Psychology	26,692	26,725	25,812	26,701	26,108	25,769	26,521	27,497	28,480	30,172	30,992
Federal	3,390	3,055	2,414	2,141	2,062	2,057	2,035	2,052	2,173	2,215	2,401
National Science Foundation	289	246	206	190	206	235	231	246	233	236	261
National Institutes of Health	1,043	926	716	600	647	622	589	630	763	720	799
Other Health & Human Svcs	885	737	607	424	396	434	361	379	361	463	475
Department of Defense	131	144	128	174	157	140	158	177	156	117	159
Other Federal	1,042	1,002	757	753	656	626	696	620	660	679	707
Non-Federal	10,088	10,960	10,746	11,178	11,630	11,893	12,361	12,190	12,385	12,945	13,341
Self-support	13,214	12,710	12,652	13,382	12,416	11,819	12,125	13,255	13,922	15,012	15,250
Social sciences	47,271	46,503	44,375	43,695	42,739	43,040	42,993	43,638	44,016	45,569	48,826
Federal	4,296	3,810	3,229	3,208	2,957	2,943	2,659	2,613	2,677	2,799	2,972
National Science Foundation	544	461	348	339	301	336	365	364	382	424	460
National Institutes of Health	350	305	207	212	211	197	202	209	207	201	210
Other Health & Human Svcs	472	362	237	139	111	124	102	115	111	112	104
Department of Defense	340	248	267	324	333	202	148	154	167	174	201
Other Federal	2,590	2,434	2,170	2,194	2,001	2,084	1,842	1,771	1,810	1,888	1,997
Non-Federal	22,078	22,467	22,532	22,354	22,145	22,102	22,725	23,679	24,434	25,348	26,722
Self-support	20,897	20,226	18,614	18,133	17,637	17,995	17,609	17,346	16,905	17,422	19,132
Total engineering	43,107	46,257	50,233	54,321	55,528	56,283	60,708	62,167	63,400	64,716	66,547
Federal	11,191	10,974	11,095	11,985	11,590	11,267	12,379	13,120	14,020	14,345	14,907
National Science Foundation	2,411	2,368	2,573	2,681	2,697	2,687	3,130	3,480	3,808	3,776	3,872
National Institutes of Health	508	446	403	477	466	455	449	515	555	644	674
Other Health & Human Svcs	157	103	102	98	78	69	87	114	73	85	122
Department of Defense	2,858	3,160	3,455	4,014	3,808	3,774	4,115	4,585	4,970	4,808	4,616
Other Federal	5,257	4,897	4,562	4,715	4,541	4,282	4,598	4,426	4,614	5,032	5,623
Non-Federal	19,162	21,518	23,420	24,666	26,259	28,206	30,645	31,205	31,712	32,865	33,742
Self-support	12,754	13,765	15,718	17,670	17,679	16,810	17,684	17,842	17,668	17,506	17,898

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington DC: NSF, 1991), unpublished tabulations; and annual series.

See figure 2-12.

Appendix table 2-21.
Full-time science and engineering graduate students, by field and mechanism of support: 1980-90
(page 1 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TOTAL SCIENCE AND ENGINEERING	215,354	219,088	222,770	230,570	232,182	235,593	244,424	248,652	252,643	259,411	267,621
Fellowships	19,455	19,084	19,592	20,041	20,284	21,017	21,571	20,658	21,285	22,095	23,830
Traineeships	10,526	10,093	9,130	8,753	8,614	8,620	8,517	9,142	9,428	9,712	10,046
Research assistantships	50,140	51,314	51,066	53,396	55,963	58,907	63,782	67,632	71,729	76,005	77,629
Teaching assistantships	51,931	53,769	56,164	58,027	59,095	59,741	60,358	60,709	61,102	62,181	62,646
Other types of support	83,302	84,828	86,818	90,353	88,226	87,308	90,196	90,511	89,099	89,418	93,470
Total sciences	172,247	172,831	172,537	176,249	176,654	179,310	183,716	186,485	189,243	194,695	201,074
Fellowships	15,698	14,907	14,899	15,194	15,409	16,206	16,625	15,983	16,797	17,383	18,662
Traineeships	9,590	9,148	8,322	7,998	7,876	7,860	7,681	8,241	8,506	8,730	9,030
Research assistantships	36,133	36,832	36,365	37,758	39,620	40,944	43,296	45,472	48,270	51,402	52,258
Teaching assistantships	44,529	45,480	46,958	47,971	48,535	48,969	49,234	49,602	49,926	51,044	51,638
Other types of support	66,297	66,464	65,993	67,328	65,214	65,331	66,880	67,187	65,744	66,136	69,486
Physical sciences	22,918	23,308	24,040	25,205	25,852	26,669	27,764	28,414	28,574	29,193	29,573
Fellowships	1,803	1,846	1,904	1,929	2,091	1,929	1,895	1,847	1,821	1,992	2,289
Traineeships	409	455	433	399	357	418	524	541	502	599	695
Research assistantships	8,340	8,607	8,768	9,145	9,628	10,284	10,994	11,558	12,056	12,426	12,137
Teaching assistantships	10,248	10,304	10,711	11,270	11,339	11,467	11,654	11,752	11,600	11,726	11,821
Other types of support	2,118	2,096	2,224	2,462	2,437	2,571	2,697	2,716	2,595	2,450	2,631
Mathematical sciences	9,902	10,154	10,823	10,964	11,319	11,833	12,398	13,049	13,523	13,705	13,870
Fellowships	760	681	687	694	766	857	909	859	940	1,001	1,103
Traineeships	145	134	126	124	159	149	128	158	204	212	189
Research assistantships	784	760	845	803	872	998	1,038	1,111	1,227	1,305	1,417
Teaching assistantships	5,607	5,748	6,074	6,445	6,624	6,814	7,154	7,461	7,598	7,845	7,803
Other types of support	2,606	2,831	3,091	2,898	2,898	3,015	3,169	3,460	3,554	3,342	3,358
Computer sciences	6,587	7,445	9,171	10,687	11,587	14,101	15,310	15,572	15,596	16,008	16,872
Fellowships	301	396	411	488	561	781	830	784	807	847	956
Traineeships	69	101	74	50	81	73	114	103	115	134	133
Research assistantships	1,036	1,098	1,191	1,403	1,635	2,076	2,354	2,837	3,054	3,340	3,341
Teaching assistantships	1,481	1,782	2,074	2,411	2,748	3,216	3,251	3,404	3,434	3,460	3,653
Other types of support	3,700	4,068	5,421	6,335	6,562	7,955	8,761	8,444	8,186	8,227	8,789
Environmental sciences	10,969	11,038	11,436	12,049	11,819	11,439	11,323	10,543	10,296	10,138	10,295
Fellowships	876	844	892	880	962	982	846	741	778	770	791
Traineeships	259	278	263	272	178	176	149	176	148	112	104
Research assistantships	3,770	3,469	3,339	3,545	3,574	3,723	3,834	3,660	3,891	4,164	4,171
Teaching assistantships	2,672	2,651	2,849	2,881	2,865	2,647	2,659	2,498	2,553	2,455	2,387
Other types of support	3,392	3,796	4,093	4,471	4,240	3,911	3,835	3,468	2,926	2,637	2,842
Life sciences	47,908	47,658	46,880	46,948	47,230	46,459	47,407	47,772	48,758	49,910	50,646
Fellowships	4,086	4,154	4,141	4,205	4,291	4,586	4,850	4,794	4,736	5,103	5,349
Traineeships	4,963	4,755	4,592	4,596	4,486	4,368	4,318	4,563	4,734	4,778	5,005
Research assistantships	14,334	14,796	14,631	14,857	15,715	15,700	16,846	17,607	18,712	20,014	20,600
Teaching assistantships	10,675	10,460	10,669	10,535	10,423	10,328	9,904	9,535	9,521	9,683	9,582
Other types of support	13,850	13,493	12,847	12,755	12,315	11,477	11,489	11,273	11,055	10,332	10,110
Psychology	26,692	26,725	25,812	26,701	26,108	25,769	26,521	27,497	28,480	30,172	30,992
Fellowships	1,601	1,304	1,232	1,270	1,295	1,277	1,422	1,433	1,538	1,506	1,654
Traineeships	2,008	1,956	1,794	1,383	1,477	1,602	1,328	1,243	1,243	1,180	1,139
Research assistantships	2,571	2,890	2,723	2,962	3,027	3,082	3,119	3,231	3,743	3,871	4,089
Teaching assistantships	4,779	5,014	4,922	5,007	5,048	5,182	5,365	5,377	5,518	5,783	5,808
Other types of support	15,733	15,561	15,141	16,079	15,261	14,626	15,287	16,213	16,438	17,832	18,302

(continued)

Appendix table 2-21.

Full-time science and engineering graduate students, by field and mechanism of support: 1980-90

(page 2 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Social sciences	47,271	46,503	44,375	43,695	42,739	43,040	42,993	43,638	44,016	45,569	48,826
Fellowships	6,271	5,682	5,632	5,728	5,443	5,794	5,873	5,525	6,177	6,164	6,520
Traineeships	1,737	1,469	1,040	1,174	1,138	1,074	1,120	1,457	1,560	1,715	1,765
Research assistantships	5,298	5,212	4,868	5,043	5,169	5,081	5,111	5,468	5,587	6,282	6,503
Teaching assistantships	9,067	9,521	9,659	9,422	9,488	9,315	9,247	9,575	9,702	10,092	10,584
Other types of support	24,898	24,619	23,176	22,328	21,501	21,776	21,642	21,613	20,990	21,316	23,454
Total engineering	43,107	46,257	50,233	54,321	55,528	56,283	60,708	62,167	63,400	64,716	66,547
Fellowships	3,757	4,177	4,693	4,847	4,875	4,811	4,946	4,675	4,488	4,712	5,168
Traineeships	936	945	808	755	738	760	836	901	922	982	1,016
Research assistantships	14,007	14,482	14,701	15,638	16,343	17,963	20,486	22,160	23,459	24,603	25,371
Teaching assistantships	7,402	8,289	9,206	10,056	10,560	10,772	11,124	11,107	11,176	11,137	11,008
Other types of support	17,005	18,364	20,825	23,025	23,012	21,977	23,316	23,324	23,355	23,282	23,984

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington DC: NSF, 1991), unpublished tabulations; and annual series.

Science & Engineering Indicators – 1991

Appendix table 2-22.
Full-time science and engineering graduate students, by source and mechanism of support: 1980-89
(page 1 of 4)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					Total science and engineering					
TOTAL SUPPORT	215,354	219,088	222,844	230,621	232,230	235,615	244,526	248,730	252,749	259,575
Fellowships	19,455	19,084	19,640	20,184	20,448	21,126	21,997	20,894	21,506	22,645
Traineeships	10,526	10,093	9,122	8,735	8,615	8,610	8,503	9,128	9,425	9,557
Research assistantships	50,140	51,314	51,081	53,412	55,976	58,930	63,813	67,681	71,776	75,924
Teaching assistantships	51,931	53,769	56,161	58,020	59,091	59,730	60,360	60,730	61,120	62,154
Mechanism unknown	83,302	84,828	86,840	90,270	88,100	87,219	89,853	90,297	88,922	89,295
Total Federal support	44,590	43,098	41,145	42,145	42,024	42,950	45,398	47,242	49,326	51,171
Fellowships	4,204	3,790	3,659	3,765	3,790	4,025	4,246	4,086	4,211	4,866
Traineeships	6,797	6,105	5,328	4,939	4,705	4,502	4,372	4,590	4,504	4,618
Research assistantships	28,718	28,527	27,723	28,580	28,822	29,643	31,915	33,961	35,680	37,186
Teaching assistantships	542	506	345	405	271	477	423	341	435	447
Mechanism unknown	4,329	4,170	4,090	4,456	4,436	4,303	4,442	4,264	4,496	4,054
National Science Foundation	9,278	9,149	9,255	9,494	9,813	10,143	10,795	11,202	11,590	11,844
Fellowships	1,312	1,262	1,288	1,290	1,321	1,377	1,492	1,479	1,576	1,765
Traineeships	215	143	89	61	49	50	26	66	62	83
Research assistantships	7,615	7,585	7,738	8,054	8,268	8,547	9,075	9,470	9,800	9,838
Teaching assistantships	35	61	27	25	28	43	74	26	58	68
Mechanism unknown	101	98	113	64	147	126	128	161	94	90
National Institutes of Health	10,614	10,132	9,583	9,673	9,972	10,083	10,770	11,527	12,408	13,023
Fellowships	673	546	456	469	518	509	531	557	564	554
Traineeships	4,526	4,166	3,954	3,788	3,747	3,609	3,459	3,650	3,611	3,559
Research assistantships	5,071	5,144	4,942	5,106	5,391	5,682	6,495	6,977	7,865	8,545
Teaching assistantships	72	64	32	72	38	53	67	79	106	110
Mechanism unknown	272	212	199	238	278	230	218	264	262	255
Other Health and Human Services	2,148	1,802	1,412	1,114	947	1,164	1,106	1,140	1,000	1,132
Fellowships	337	210	161	132	123	132	100	93	69	97
Traineeships	1,159	1,021	727	434	303	312	341	279	272	265
Research assistantships	502	502	439	477	474	610	595	713	632	745
Teaching assistantships	22	6	30	12	3	7	2	12	3	6
Mechanism unknown	128	63	55	59	44	103	68	43	24	19
Department of Defense	5,086	5,485	5,749	6,751	6,873	7,052	7,713	8,565	9,277	8,886
Fellowships	196	161	182	245	207	237	275	346	332	495
Traineeships	65	67	27	27	36	36	72	113	121	96
Research assistantships	2,927	3,287	3,448	3,904	4,051	4,152	4,608	5,559	5,974	5,778
Teaching assistantships	0	0	0	0	0	0	0	0	0	0
Mechanism unknown	1,898	1,970	2,092	2,575	2,579	2,627	2,758	2,547	2,850	2,517
Other Federal	17,464	16,530	15,146	15,113	14,419	14,508	15,014	14,808	15,051	16,286
Fellowships	1,686	1,611	1,572	1,629	1,621	1,770	1,848	1,611	1,670	1,955
Traineeships	832	708	531	629	570	495	474	482	438	615
Research assistantships	12,603	12,009	11,156	11,039	10,638	10,652	11,142	11,242	11,409	12,280
Teaching assistantships	413	375	256	296	202	374	280	224	268	263
Mechanism unknown	1,930	1,827	1,631	1,520	1,388	1,217	1,270	1,249	1,266	1,173
Non-Federal support	104,440	109,282	113,532	116,884	120,457	123,958	129,134	130,848	133,734	137,258
Fellowships	15,251	15,294	15,981	16,419	16,658	17,101	17,751	16,808	17,295	17,779
Traineeships	3,729	3,988	3,794	3,796	3,910	4,108	4,131	4,538	4,921	4,939
Research assistantships	21,422	22,787	23,358	24,832	27,154	29,287	31,898	33,720	36,096	38,738
Teaching assistantships	51,389	53,263	55,816	57,615	58,820	59,253	59,937	60,389	60,685	61,707
Mechanism unknown	12,649	13,950	14,583	14,222	13,915	14,209	15,417	15,393	14,737	14,095

(continued)

Appendix table 2-22.

Full-time science and engineering graduate students, by source and mechanism of support: 1980-89

(page 2 of 4)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Self-support	66,324	66,708	68,167	71,592	69,749	68,707	69,994	70,640	69,689	71,146
Fellowships	0	0	0	0	0	0	0	0	0	0
Traineeships	0	0	0	0	0	0	0	0	0	0
Research assistantships	0	0	0	0	0	0	0	0	0	0
Teaching assistantships	0	0	0	0	0	0	0	0	0	0
Mechanism unknown	66,324	66,708	68,167	71,592	69,749	68,707	69,994	70,640	69,689	71,146
Total sciences										
TOTAL SUPPORT	172,247	172,831	172,605	176,294	176,691	179,322	183,800	186,501	189,271	194,995
Fellowships	15,698	14,907	14,947	15,337	15,573	16,315	17,051	16,204	17,007	17,864
Traineeships	9,590	9,148	8,309	7,980	7,877	7,850	7,667	8,227	8,498	8,575
Research assistantships	36,133	36,832	36,380	37,774	39,631	40,965	43,323	45,512	48,308	51,288
Teaching assistantships	44,529	45,480	46,955	47,961	48,528	48,958	49,236	49,605	49,924	51,014
Mechanism unknown	66,297	66,464	66,014	67,242	65,082	65,234	66,523	66,953	65,534	66,254
Total Federal support	33,399	32,124	30,050	30,160	30,434	31,683	33,019	34,111	35,295	36,918
Fellowships	3,557	3,156	2,948	2,981	2,981	3,221	3,416	3,255	3,334	3,860
Traineeships	6,387	5,788	5,061	4,673	4,492	4,286	4,165	4,333	4,288	4,379
Research assistantships	20,170	19,992	19,146	19,570	20,146	21,216	22,357	23,590	24,700	25,904
Teaching assistantships	403	406	305	365	251	383	391	317	361	373
Mechanism unknown	2,882	2,782	2,590	2,571	2,564	2,577	2,690	2,616	2,612	2,402
National Science Foundation	6,867	6,781	6,682	6,813	7,116	7,456	7,665	7,722	7,782	8,068
Fellowships	1,141	1,094	1,035	1,030	1,055	1,114	1,231	1,187	1,223	1,347
Traineeships	183	132	87	60	45	37	25	58	54	63
Research assistantships	5,444	5,449	5,449	5,642	5,897	6,192	6,262	6,345	6,395	6,539
Teaching assistantships	31	31	21	22	26	31	69	24	35	52
Mechanism unknown	68	75	90	59	93	82	78	108	75	67
National Institutes of Health	10,106	9,686	9,180	9,196	9,506	9,628	10,321	11,012	11,853	12,379
Fellowships	665	539	447	453	486	477	515	540	531	523
Traineeships	4,382	4,039	3,876	3,688	3,677	3,518	3,372	3,551	3,552	3,491
Research assistantships	4,738	4,851	4,631	4,754	5,037	5,355	6,160	6,593	7,406	8,008
Teaching assistantships	70	60	32	69	36	52	66	79	106	110
Mechanism unknown	251	197	194	232	270	226	208	249	258	247
Other Health and Human Services	1,991	1,699	1,310	1,016	869	1,095	1,019	1,026	927	1,058
Fellowships	278	185	139	102	93	112	71	81	64	89
Traineeships	1,118	993	708	427	299	306	325	266	263	255
Research assistantships	448	459	388	421	431	567	554	630	576	689
Teaching assistantships	21	6	27	12	3	7	2	12	1	6
Mechanism unknown	126	56	48	54	43	103	67	37	23	19
Department of Defense	2,228	2,325	2,294	2,737	3,065	3,278	3,598	3,978	4,305	4,066
Fellowships	143	86	88	145	87	115	167	194	187	338
Traineeships	52	36	5	26	16	25	38	74	71	44
Research assistantships	1,241	1,384	1,366	1,579	1,905	1,983	2,085	2,518	2,868	2,618
Teaching assistantships	0	0	0	0	0	0	0	0	0	0
Mechanism unknown	792	819	835	987	1,057	1,155	1,308	1,192	1,179	1,066
Other Federal	12,207	11,633	10,584	10,398	9,878	10,226	10,416	10,373	10,428	11,347
Fellowships	1,330	1,252	1,239	1,251	1,260	1,403	1,432	1,253	1,329	1,563
Traineeships	652	588	385	472	455	400	405	384	348	526
Research assistantships	8,299	7,849	7,312	7,174	6,876	7,119	7,296	7,504	7,455	8,050
Teaching assistantships	281	309	225	262	186	293	254	202	219	205
Mechanism unknown	1,645	1,635	1,423	1,239	1,101	1,011	1,029	1,030	1,077	1,003

(continued)

Appendix table 2-22.

Full-time science and engineering graduate students, by source and mechanism of support: 1980-89

(page 3 of 4)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Non-Federal support	85,278	87,764	90,107	92,215	94,192	95,750	98,483	99,612	101,986	104,623
Fellowships	12,141	11,751	11,999	12,356	12,592	13,094	13,635	12,949	13,673	14,004
Traineeships	3,203	3,360	3,248	3,307	3,385	3,564	3,502	3,894	4,210	4,196
Research assistantships	15,963	16,840	17,234	18,204	19,485	19,749	20,966	21,922	23,608	25,384
Teaching assistantships	44,126	45,074	46,650	47,596	48,277	48,575	48,845	49,288	49,563	50,641
Mechanism unknown	9,845	10,739	10,976	10,752	10,453	10,768	11,535	11,559	10,932	10,398
Self-support	53,570	52,943	52,448	53,919	52,065	51,889	52,298	52,778	51,990	53,454
Fellowships	0	0	0	0	0	0	0	0	0	0
Traineeships	0	0	0	0	0	0	0	0	0	0
Research assistantships	0	0	0	0	0	0	0	0	0	0
Teaching assistantships	0	0	0	0	0	0	0	0	0	0
Mechanism unknown	53,570	52,943	52,448	53,919	52,065	51,889	52,298	52,778	51,990	53,454
Total engineering										
TOTAL SUPPORT	43,107	46,257	50,239	54,327	55,539	56,293	60,726	62,229	63,478	64,580
Fellowships	3,757	4,177	4,693	4,847	4,875	4,811	4,946	4,690	4,499	4,781
Traineeships	936	945	813	755	738	760	836	901	927	982
Research assistantships	14,007	14,482	14,701	15,638	16,345	17,965	20,490	22,169	23,468	24,636
Teaching assistantships	7,402	8,289	9,206	10,059	10,563	10,772	11,124	11,125	11,196	11,140
Mechanism unknown	17,005	18,364	20,826	23,028	23,018	21,985	23,330	23,344	23,388	23,041
Total Federal support	11,191	10,974	11,095	11,985	11,590	11,267	12,379	13,131	14,031	14,253
Fellowships	647	634	711	784	809	804	830	831	877	1,006
Traineeships	410	317	267	266	213	216	207	257	216	239
Research assistantships	8,548	8,535	8,577	9,010	8,676	8,427	9,558	10,371	10,980	11,282
Teaching assistantships	139	100	40	40	20	94	32	24	74	74
Mechanism unknown	1,447	1,388	1,500	1,885	1,872	1,726	1,752	1,648	1,884	1,652
National Science Foundation	2,411	2,368	2,573	2,681	2,697	2,687	3,130	3,480	3,808	3,776
Fellowships	171	168	253	260	266	263	261	292	353	418
Traineeships	32	11	2	1	4	13	1	8	8	20
Research assistantships	2,171	2,136	2,289	2,412	2,371	2,355	2,813	3,125	3,405	3,299
Teaching assistantships	4	30	6	3	2	12	5	2	23	16
Mechanism unknown	33	23	23	5	54	44	50	53	19	23
National Institutes of Health	508	446	403	477	466	455	449	515	555	644
Fellowships	8	7	9	16	32	32	16	17	33	31
Traineeships	144	127	78	100	70	91	87	99	59	68
Research assistantships	333	293	311	352	354	327	335	384	459	537
Teaching assistantships	2	4	0	3	2	1	1	0	0	0
Mechanism unknown	21	15	5	6	8	4	10	15	4	8
Other Health and Human Services	157	103	102	98	78	69	87	114	73	74
Fellowships	59	25	22	30	30	20	29	12	5	8
Traineeships	41	28	19	7	4	6	16	13	9	10
Research assistantships	54	43	51	56	43	43	41	83	56	56
Teaching assistantships	1	0	3	0	0	0	0	0	2	0
Mechanism unknown	2	7	7	5	1	0	1	6	1	0
Department of Defense	2,858	3,160	3,455	4,014	3,808	3,774	4,115	4,587	4,972	4,820
Fellowships	53	75	94	100	120	122	108	152	145	157
Traineeships	13	31	22	1	20	11	34	39	50	52
Research assistantships	1,686	1,903	2,082	2,325	2,146	2,169	2,523	3,041	3,106	3,160
Teaching assistantships	0	0	0	0	0	0	0	0	0	0
Mechanism unknown	1,106	1,151	1,257	1,588	1,522	1,472	1,450	1,355	1,671	1,451

(continued)

Appendix table 2-22.

Full-time science and engineering graduate students, by source and mechanism of support: 1980-89

(page 4 of 4)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Other Federal	5,257	4,897	4,562	4,715	4,541	4,282	4,598	4,435	4,623	4,939
Fellowships	356	359	333	378	361	367	416	358	341	392
Traineeships	180	120	146	157	115	95	69	98	90	89
Research assistantships	4,304	4,160	3,844	3,865	3,762	3,533	3,846	3,738	3,954	4,230
Teaching assistantships	132	66	31	34	16	81	26	22	49	58
Mechanism unknown	285	192	208	281	287	206	241	219	189	170
Non-Federal support	19,162	21,518	23,425	24,669	26,265	28,208	30,651	31,236	31,748	32,635
Fellowships	3,110	3,543	3,982	4,063	4,066	4,007	4,116	3,859	3,622	3,775
Traineeships	526	628	546	489	525	544	629	644	711	743
Research assistantships	5,459	5,947	6,124	6,628	7,669	9,538	10,932	11,798	12,488	13,354
Teaching assistantships	7,263	8,189	9,166	10,019	10,543	10,678	11,092	11,101	11,122	11,066
Mechanism unknown	2,804	3,211	3,607	3,470	3,462	3,441	3,882	3,834	3,805	3,697
Self-support	12,754	13,765	15,719	17,673	17,684	16,818	17,696	17,862	17,699	17,692
Fellowships	0	0	0	0	0	0	0	0	0	0
Traineeships	0	0	0	0	0	0	0	0	0	0
Research assistantships	0	0	0	0	0	0	0	0	0	0
Teaching assistantships	0	0	0	0	0	0	0	0	0	0
Mechanism unknown	12,754	13,765	15,719	17,673	17,684	16,818	17,696	17,862	17,699	17,692

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington DC: NSF, 1991), unpublished tabulations; and annual series.

See figure 2-13.

Science & Engineering Indicators – 1991

Appendix table 2-23.
Science and engineering graduate students, by field and citizenship: 1983-90

	1983	1984	1985	1986	1987	1988	1989	1990
Total								
Total science & engineering	349,547	352,027	360,722	370,487	376,632	378,274	386,047	401,569
Total sciences	257,610	258,383	263,771	267,416	271,988	274,555	281,232	292,270
Physical sciences	29,466	30,064	30,995	32,260	32,738	32,972	33,628	34,337
Mathematics	17,397	17,478	17,613	17,990	18,573	19,141	19,382	19,884
Computer sciences	23,616	25,810	29,844	31,425	32,137	32,787	32,846	34,507
Environmental sciences	15,544	15,612	15,545	15,163	14,522	14,032	13,848	14,159
Life sciences	58,345	58,233	57,918	58,545	59,456	59,316	60,655	62,104
Psychology	41,039	41,074	41,308	41,551	42,888	44,389	46,304	48,659
Social sciences	72,203	70,112	70,548	70,482	71,674	71,918	74,569	78,620
Total engineering	91,937	93,644	96,951	103,071	104,644	103,719	104,815	109,299
U.S. citizens								
Total science & engineering	278,994	279,554	283,741	286,279	287,606	284,243	287,681	299,110
Total sciences	214,676	213,916	215,725	215,349	216,457	215,893	219,731	227,938
Physical sciences	21,805	22,017	22,054	22,232	22,110	21,860	21,820	21,826
Mathematics	12,442	12,285	12,262	12,179	12,443	12,716	12,711	13,443
Computer sciences	18,068	19,451	22,386	23,419	23,409	23,717	23,122	23,778
Environmental sciences	13,679	13,808	13,651	13,067	12,299	11,589	11,247	11,442
Life sciences	49,567	49,208	48,366	47,918	47,785	46,612	46,878	47,391
Psychology	39,605	39,685	39,811	40,047	41,346	42,726	44,652	46,819
Social sciences	59,510	57,462	57,195	56,487	57,065	56,673	59,301	63,239
Total engineering	64,318	65,638	68,016	70,930	71,149	68,350	67,950	71,172
Foreign citizens								
Total science & engineering	70,553	72,473	76,981	84,208	89,026	94,031	98,366	102,459
Total sciences	42,934	44,467	48,046	52,067	55,531	58,662	61,501	64,332
Physical sciences	7,661	8,047	8,941	10,028	10,628	11,112	11,808	12,511
Mathematics	4,955	5,193	5,351	5,811	6,130	6,425	6,671	6,441
Computer sciences	5,548	6,359	7,458	8,006	8,728	9,070	9,724	10,729
Environmental sciences	1,865	1,804	1,894	2,096	2,223	2,443	2,601	2,717
Life sciences	8,778	9,025	9,552	10,627	11,671	12,704	13,777	14,713
Psychology	1,434	1,389	1,497	1,504	1,542	1,663	1,652	1,840
Social sciences	12,693	12,650	13,353	13,995	14,609	15,245	15,268	15,381
Total engineering	27,619	28,006	28,935	32,141	33,495	35,369	36,865	38,127

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1990*, NSF 91-320 (Washington DC: NSF, 1991), unpublished tabulations; and annual series.

See figure 2-14 and figure O-17 in Overview.

Science & Engineering Indicators – 1991

Appendix table 2-24.
Science and engineering doctoral recipients, by field and citizenship: 1980-90
(page 1 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total											
Total, all doctorates	31,020	31,357	31,111	31,282	31,337	31,297	31,895	32,364	33,490	34,319	36,027
Total science and engineering	17,523	17,996	18,017	18,393	18,514	18,712	19,251	19,707	20,741	21,530	22,673
Total sciences	15,044	15,468	15,371	15,612	15,601	15,546	15,875	15,995	16,551	16,986	17,781
Physical sciences	2,521	2,627	2,694	2,802	2,845	2,916	3,090	3,212	3,317	3,244	3,494
Mathematics	744	728	720	701	698	688	729	740	749	859	892
Computer sciences	218	232	220	286	295	310	399	450	515	612	704
Environmental sciences	628	583	657	637	614	617	589	628	728	740	769
Life sciences	4,715	4,786	4,844	4,756	4,877	4,904	4,805	4,816	5,127	5,203	5,509
Psychology	3,098	3,358	3,159	3,347	3,257	3,117	3,124	3,169	3,064	3,203	3,267
Social sciences	3,120	3,154	3,077	3,083	3,015	2,994	3,139	2,980	3,051	3,125	3,146
Total engineering	2,479	2,528	2,646	2,781	2,913	3,166	3,376	3,712	4,190	4,544	4,892
U.S. citizens											
Total, all doctorates	25,222	25,061	24,391	34,259	34,027	23,370	23,081	22,983	23,287	23,398	24,190
Total science and engineering	13,400	13,544	13,292	13,413	13,250	12,947	12,869	12,820	12,217	13,311	13,618
Total sciences	12,145	12,374	12,123	12,250	12,011	11,668	11,486	11,262	10,436	11,447	11,691
Physical sciences	1,884	1,956	1,991	2,064	2,071	2,043	2,014	2,080	2,100	1,973	2,077
Mathematics	520	482	458	411	407	376	366	345	342	393	369
Computer sciences	156	168	143	180	178	189	202	243	284	338	343
Environmental sciences	512	472	528	483	474	442	422	425	511	529	521
Life sciences	3,849	3,891	3,964	3,869	3,910	3,831	3,703	3,566	2,670	3,724	3,726
Psychology	2,849	3,111	2,876	3,044	2,935	2,805	2,766	2,747	2,667	2,684	2,790
Social sciences	2,375	2,294	2,163	2,199	2,036	1,982	2,013	1,856	1,862	1,806	1,865
Total engineering	1,255	1,170	1,169	1,163	1,239	1,279	1,383	1,558	1,781	1,864	1,927
Permanent residents											
Total, all doctorates	1,290	1,281	1,228	1,275	1,224	1,324	1,432	1,578	1,624	1,626	1,654
Total science and engineering	952	893	854	898	835	929	987	1,086	1,129	1,121	1,158
Total sciences	653	592	558	579	561	614	644	731	762	756	782
Physical sciences	151	147	119	120	119	135	133	147	136	146	167
Mathematics	62	43	41	46	36	42	36	51	44	35	47
Computer sciences	13	20	12	27	17	24	47	32	42	58	53
Environmental sciences	26	16	29	30	25	32	24	25	31	30	23
Life sciences	186	159	140	150	149	151	165	208	263	227	241
Psychology	50	47	47	64	51	59	65	59	61	54	69
Social sciences	165	160	170	142	164	171	174	209	185	206	182
Total engineering	299	301	296	319	274	315	343	355	367	365	376

(continued)

Appendix table 2-24.

Science and engineering doctoral recipients, by field and citizenship: 1980-90

(page 2 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
					Temporary residents						
Total, all doctorates	3,644	3,940	4,204	4,499	4,832	5,228	5,276	4,610	6,195	6,648	7,744
Total science and engineering	2,710	2,962	3,127	3,400	3,692	4,028	4,141	4,450	4,920	5,378	6,286
Total sciences	1,859	2,020	2,097	2,230	2,423	2,609	2,769	2,918	3,198	3,437	4,095
Physical sciences	426	442	506	539	564	620	758	798	865	888	1,021
Mathematics	139	186	192	209	232	238	272	302	305	346	413
Computer sciences	43	40	59	72	89	89	123	143	176	178	263
Environmental sciences	80	85	81	106	106	119	106	125	137	124	171
Life sciences	592	613	603	629	675	779	711	781	902	964	1,245
Psychology	71	80	65	79	88	81	81	85	84	106	116
Social sciences	508	574	591	596	669	683	718	684	729	831	866
Total engineering	851	942	1,030	1,170	1,269	1,419	1,372	1,532	1,722	1,941	2,191

[1] Includes those who did not report their citizenship status.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations from the Survey of Earned Doctorates.

See figure 2-14 and figure O-17 in Overview.

Science & Engineering Indicators – 1991

Appendix table 2-25

Natural science and engineering bachelors degrees, by country: 1975-90

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Natural sciences																
North America and USSR																
Canada	8,338	9,019	9,559	9,803	9,312	9,210	8,818	9,456	10,041	11,331	12,876	14,200	14,039	14,456	13,966	NA
United States	117,988	121,722	123,087	121,861	120,621	119,645	120,387	123,346	125,712	131,163	138,275	138,993	134,984	125,531	116,343	NA
USSR	98,800	102,171	105,738	108,981	111,521	116,700	119,200	121,000	121,200	122,800	122,400	119,228	106,400	106,700	NA	NA
Europe																
France	6,746	6,821	7,064	7,316	7,576	7,846	8,126	8,415	8,715	9,406	10,009	11,391	12,068	12,391	13,270	14,320
Italy	10,915	11,293	11,372	11,120	10,267	10,735	11,268	11,417	11,062	11,667	11,971	12,047	12,765	13,012	NA	NA
Sweden	906	898	810	733	718	628	582	583	740	857	913	1,075	1,256	1,347	NA	NA
United Kingdom	17,280	17,280	17,937	18,287	18,562	18,850	21,425	22,107	19,098	18,634	18,060	17,471	16,663	16,434	NA	NA
West Germany	6,510	6,426	7,239	7,618	7,571	8,043	8,939	9,266	10,124	10,802	11,507	12,419	12,925	14,714	NA	NA
Asia																
China	NA	NA	NA	NA	NA	NA	NA	76,842	40,301	35,481	36,493	39,773	42,082	NA	NA	NA
India	123,353	118,671	114,223	110,004	106,004	109,217	112,669	116,232	119,912	123,165	128,236	129,964	133,257	137,419	NA	NA
Japan	18,984	19,977	20,689	21,625	23,871	22,736	23,358	22,771	22,381	23,423	23,626	23,805	24,655	23,972	23,547	NA
Singapore	466	490	335	347	528	573	460	577	663	726	854	945	1,012	982	1,166	1,278
South Korea	5,657	5,791	6,175	6,699	7,279	7,922	9,006	10,448	11,394	12,486	15,068	15,235	16,626	21,547	22,550	23,195
Taiwan	3,700	4,111	3,946	4,126	4,151	4,334	4,341	4,491	4,674	4,661	4,987	5,251	5,472	5,990	NA	NA
Engineering																
North America and USSR																
Canada	4,584	4,842	5,155	5,923	6,696	7,228	7,226	7,348	7,987	8,328	8,589	8,403	8,835	7,887	7,781	NA
United States	40,065	39,114	41,581	47,411	53,720	59,240	64,068	67,791	72,954	76,531	77,871	77,061	74,705	70,406	67,214	NA
USSR	272,100	280,400	291,400	300,100	306,800	319,800	327,000	330,300	331,500	335,400	334,900	330,700	288,300	281,100	NA	NA
Europe																
France	9,956	10,264	10,176	10,429	11,100	11,548	11,754	12,156	12,650	12,670	13,659	13,722	14,576	14,998	16,658	17,019
Italy	6,949	10,808	10,798	10,788	10,777	10,767	10,757	10,663	10,570	10,477	10,386	10,295	10,794	11,318	11,867	NA
Sweden	1,724	1,796	1,745	1,695	1,713	1,766	1,821	1,878	1,891	2,113	1,947	2,086	2,455	2,346	NA	NA
United Kingdom	10,087	10,087	10,930	11,937	12,575	13,248	12,299	11,696	10,600	10,577	10,438	10,300	9,618	9,932	NA	NA
West Germany	3,810	4,242	4,499	5,105	5,120	5,449	5,639	6,023	6,469	6,826	6,734	7,216	7,246	8,675	9,579	NA
Asia																
China	NA	NA	NA	NA	NA	NA	NA	145,263	89,726	77,388	63,132	72,703	92,994	NA	NA	NA
India	14,607	15,217	15,852	16,514	17,236	17,921	18,669	19,448	20,260	20,707	21,088	24,096	27,057	28,500	NA	NA
Japan	66,512	68,126	70,431	72,466	75,409	74,737	76,370	74,774	70,824	71,640	72,560	74,516	77,077	77,503	77,009	NA
Singapore	236	241	290	240	272	288	323	349	585	585	769	924	907	1,452	1,129	1,347
South Korea	7,155	7,272	7,858	8,919	10,124	11,492	13,044	14,806	20,636	22,190	23,539	27,612	27,600	26,891	28,141	28,071
Taiwan	5,000	5,142	5,258	5,559	6,315	6,463	7,299	7,309	7,320	7,330	7,703	7,730	7,508	7,994	NA	NA

NA = not available

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations. See chapter 2 References for country sources.

See figures 2-15, 2-16, and 2-17, and text table 2-2.

Science & Engineering Indicators – 1991

Appendix table 2-26.

Natural science and engineering degrees as a percentage of 22-year-olds, by country: 1975-90

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Percent															
Western countries and USSR																
France	1.97	2.02	2.03	2.09	2.21	2.40	2.46	2.42	2.46	2.58	2.75	2.93	3.12	3.21	NA	NA
Italy	2.34	2.38	2.34	2.27	2.13	2.15	2.15	2.08	1.96	2.07	2.13	2.19	2.47	2.51	NA	NA
United Kingdom	NA	3.48	3.62	3.75	3.82	3.89	3.97	3.87	3.31	3.16	3.00	2.96	2.83	2.87	NA	NA
United States	4.05	3.88	3.75	3.65	3.55	4.14	4.29	4.46	4.65	4.88	5.10	5.22	5.19	4.97	4.60	NA
USSR	8.35	8.44	8.59	8.67	8.69	8.89	9.16	9.34	9.45	9.65	9.71	9.81	8.84	8.93	NA	NA
West Germany	1.23	1.24	1.34	1.32	1.38	1.53	1.58	1.44	1.54	1.57	1.62	1.76	1.82	2.13	NA	NA
Asia																
China	NA	NA	NA	NA	NA	NA	NA	1.18	0.66	0.55	0.46	0.50	0.58	0.56	NA	NA
India	1.29	1.21	1.14	1.08	1.02	1.02	1.03	1.04	1.05	1.05	1.06	1.07	1.08	1.09	NA	NA
Japan	4.67	4.96	5.28	5.61	6.10	6.16	6.26	6.08	5.77	5.85	5.88	5.90	6.00	5.88	5.72	NA
Singapore	1.40	1.41	1.17	1.06	1.40	1.45	1.33	1.58	2.15	2.27	2.83	3.40	3.63	4.79	4.70	NA
South Korea	2.07	2.00	2.03	2.13	2.24	2.37	2.66	3.03	3.80	4.08	4.51	5.00	5.17	5.66	5.92	5.99
Taiwan	NA	2.59	2.53	2.61	2.76	2.75	3.01	2.99	3.01	2.99	3.18	3.26	3.32	3.61	NA	NA

NA = not available

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figure 2-18.

Appendix table 2-27.

Population of 20- to 24-year-olds, by country: 1975-2010

	1975	1980	1985	1990	1995	2000	2005	2010
Western countries and USSR								
France	4,247	4,228	4,296	4,247	4,202	3,696	3,780	3,860
Italy	3,819	4,042	4,617	4,726	4,415	3,704	3,050	3,062
United Kingdom	3,891	4,125	4,747	4,493	3,882	3,396	3,606	3,776
United States	19,527	21,584	21,208	18,788	17,292	17,010	18,188	18,396
USSR	22,199	24,553	23,555	20,583	21,431	23,051	25,017	25,277
West Germany	5,550	5,986	6,598	6,306	4,606	3,951	4,146	4,203
Asia								
China	90,236	86,505	107,785	128,692	124,198	96,821	92,344	108,403
India	53,509	62,367	70,207	78,284	86,970	91,549	105,460	114,409
Japan	9,155	7,906	8,184	8,942	10,009	8,503	7,432	6,919
Singapore	296	296	287	234	223	193	209	215
South Korea	3,089	4,103	4,281	4,281	4,374	4,563	3,999	3,740
Taiwan	1,710	1,895	2,002	1,906	1,806	2,029	1,861	1,524

SOURCES: UNESCO, *Statistical Yearbooks* for appropriate years; and unpublished tabulations.

Science & Engineering Indicators – 1991

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Appendix table 2-28.

Natural science and engineering bachelors degrees as a percentage of total degrees, by country: 1975-90

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Natural sciences																
	Percent															
North America and USSR																
Canada	NA	10	10	10	9	9	9	9	10	10	11	12	12	12	11	NA
United States	13	13	13	13	13	13	13	13	13	13	14	14	13	12	11	NA
USSR	14	14	14	14	14	14	14	14	14	14	14	14	14	14	NA	NA
Europe																
France	19	18	17	17	16	15	15	14	14	14	14	16	16	16	NA	NA
Italy	16	18	18	18	18	19	19	19	18	18	18	18	18	18	17	NA
Sweden	7	5	5	5	5	4	3	3	4	4	5	7	8	8	NA	NA
United Kingdom	NA	NA	NA	NA	15	15	17	17	14	13	12	12	11	10	NA	NA
West Germany	19	18	19	19	18	17	19	18	18	19	19	19	19	20	21	NA
Asia																
China	NA	NA	NA	NA	NA	NA	NA	18	13	14	14	14	13	12	NA	NA
India	NA	25	24	22	24	25	30	29	28	27	27	26	26	26	NA	NA
Japan	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	NA
Singapore	NA	20	21	15	15	19	22	21	24	23	20	20	20	20	20	21
South Korea	NA	17	17	16	16	16	16	17	15	14	13	11	11	13	14	14
Taiwan	NA	NA	14	13	13	13	13	13	14	14	13	14	14	14	15	NA
Engineering																
North America and USSR																
Canada	NA	5	5	6	7	7	7	7	8	8	8	7	7	6	6	NA
United States	4	4	4	5	6	6	7	7	7	8	8	8	7	7	7	NA
USSR	38	37	38	38	38	39	39	39	39	39	39	39	38	36	NA	NA
Europe																
France	28	27	25	24	23	23	21	21	20	19	19	19	19	19	NA	NA
Italy	10	16	15	15	15	15	15	15	15	15	14	14	14	14	14	NA
Sweden	13	10	11	11	11	11	10	10	10	10	11	13	15	14	NA	NA
United Kingdom	NA	NA	NA	NA	10	11	10	9	8	7	7	7	6	6	NA	NA
West Germany	11	12	12	13	12	12	12	12	12	12	11	11	10	12	12	NA
Asia																
China	NA	NA	NA	NA	NA	NA	NA	35	30	31	25	24	27	26	NA	NA
India	NA	3	3	3	3	3	4	4	4	4	3	4	4	4	NA	NA
Japan	21	21	21	20	20	20	20	20	19	19	19	20	20	20	20	NA
Singapore	10	12	14	12	12	13	18	18	25	19	21	22	21	31	22	NA
South Korea	NA	21	21	22	22	23	23	24	27	24	20	20	18	17	17	17
Taiwan	NA	18	18	18	20	19	23	22	22	21	22	21	19	21	NA	NA

NA = not available

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

Appendix table 3-1.
Total and scientist and engineer employment, by industry: 1980, 1983, 1986, and 1989
(page 1 of 4)

Industry	Number of jobs			
	1980	1983	1986	1989
	Thousands			
TOTAL PRIVATE				
All occupations	66,160	65,556	73,279	79,501
All scientists and engineers	1,366	1,523	1,702	1,917
Scientists	374	425	498	568
Life	19	26	29	34
Mathematical	45	59	66	79
Physical	108	110	113	112
Social	26	29	25	25
Computer specialists	175	201	264	318
Engineers	992	1,098	1,204	1,349
Aeronautical/astronautical	27	33	59	57
Chemical	45	47	42	41
Civil	79	104	94	103
Electrical/electronic	273	319	377	436
Industrial	133	103	120	124
Mechanical	198	199	196	208
Other[1]	237	294	317	381
MANUFACTURING				
All occupations	20,286	18,434	18,964	19,442
All scientists and engineers	745	814	927	993
Scientists	140	144	175	193
Life	11	15	18	23
Mathematical	13	12	14	12
Physical	64	57	57	55
Social	1	1	1	1
Computer specialists	52	59	85	103
Engineers	605	670	753	804
Aeronautical/astronautical	23	29	52	49
Chemical	33	36	34	31
Civil	7	8	8	8
Electrical/electronic	159	206	234	256
Industrial	123	89	104	104
Mechanical	126	135	135	143
Other[1]	135	167	185	213
NONMANUFACTURING				
All occupations	45,874	47,122	54,315	60,059
All scientists and engineers	621	709	775	920
Scientists	234	281	323	375
Life	8	11	12	11
Mathematical	33	47	53	67
Physical	44	53	56	57
Social	25	28	24	24
Computer specialists	124	142	179	216
Engineers	387	428	452	545
Aeronautical/astronautical	4	4	6	8
Chemical	12	11	8	9
Civil	73	95	86	94
Electrical/electronic	113	113	144	180
Industrial	10	14	15	20
Mechanical	72	64	61	65
Other[1]	102	127	131	168

(continued)

Appendix table 3-1.

Total and scientist and engineer employment, by industry: 1980, 1983, 1986, and 1989
(page 2 of 4)

Industry	Number of jobs			
	1980	1983	1986	1989
	Thousands			
Mining				
All occupations	1,027	952	777	693
All scientists and engineers	55	65	56	47
Scientists	26	30	26	21
Life	0	0	0	0
Mathematical	0	0	0	0
Physical	21	25	22	18
Social	0	0	0	0
Computer specialists	4	5	4	3
Engineers	29	35	30	26
Aeronautical/astronautical	0	0	0	0
Chemical	1	1	1	1
Civil	1	2	1	1
Electrical/electronic	2	1	1	1
Industrial	0	0	0	0
Mechanical	1	3	2	2
Other[1]	24	28	25	21
Construction				
All occupations	4,346	3,948	4,816	5,187
All scientists and engineers	53	48	32	22
Scientists	1	1	1	1
Life	0	0	0	0
Mathematical	0	0	0	0
Physical	0	0	0	0
Social	0	0	0	0
Computer specialists	1	1	1	1
Engineers	52	47	31	21
Aeronautical/astronautical	0	0	0	0
Chemical	0	0	0	0
Civil	18	19	10	7
Electrical/electronic	7	6	5	3
Industrial	0	1	1	1
Mechanical	10	7	5	4
Other[1]	17	13	10	6
Communications/transportation/utilities				
All occupations	5,146	4,954	5,255	5,644
All scientists and engineers	95	114	110	113
Scientists	13	32	32	32
Life	0	0	1	0
Mathematical	1	4	2	2
Physical	0	0	2	2
Social	0	1	2	0
Computer specialists	11	10	19	26
Engineers	82	81	78	81
Aeronautical/astronautical	1	1	1	1
Chemical	1	1	1	1
Civil	5	7	8	7
Electrical/electronic	43	40	38	39
Industrial	4	6	5	8
Mechanical	7	6	6	5
Other[1]	20	21	20	20

(continued)

Appendix table 3-1.
Total and scientist and engineer employment, by industry: 1980, 1983, 1986, and 1989
(page 3 of 4)

Industry	Number of jobs			
	1980	1983	1986	1989
	Thousands			
Trade				
All occupations	20,310	20,880	23,683	25,769
All scientists and engineers	66	66	72	97
Scientists	26	30	27	21
Life	0	1	1	0
Mathematical	0	2	0	0
Physical	1	2	2	0
Social	0	0	0	0
Computer specialists	25	26	24	21
Engineers	40	36	45	76
Aeronautical/astronautical	0	0	0	0
Chemical	3	0	0	0
Civil	0	0	0	0
Electrical/electronic	16	11	16	21
Industrial	0	0	0	0
Mechanical	18	9	7	6
Other[1]	3	15	23	49
Financial services				
All occupations	5,160	5,468	6,283	6,695
All scientists and engineers	52	73	95	134
Scientists	46	64	86	116
Life	0	0	0	0
Mathematical	16	23	27	38
Physical	0	0	0	0
Social	2	7	6	7
Computer specialists	28	33	52	71
Engineers	5	8	10	19
Aeronautical/astronautical	0	0	0	0
Chemical	0	0	0	0
Civil	0	0	0	0
Electrical/electronic	0	0	0	0
Industrial	0	0	0	0
Mechanical	0	0	0	0
Other[1]	5	8	10	19
Business and related services				
All occupations	9,885	10,920	13,501	16,071
All scientists and engineers	301	356	416	508
Scientists	122	134	159	185
Life	7	9	10	11
Mathematical	15	18	24	28
Physical	22	26	30	37
Social	23	20	16	17
Computer specialists	54	61	80	93
Engineers	179	222	257	323
Aeronautical/astronautical	3	3	6	7
Chemical	9	8	6	7
Civil	49	68	67	80
Electrical/electronic	46	55	84	116
Industrial	5	6	10	12
Mechanical	35	39	40	48
Other[1]	32	42	45	53

(continued)

Appendix table 3-1.
Total and scientist and engineer employment, by industry: 1980, 1983, 1986, and 1989
(page 4 of 4)

NOTES: Details may not sum to totals because of rounding. The Standard Industrial Classification numbers are:

Manufacturing	20-39
Nonmanufacturing	
Mining	10-14
Construction	15-17
Communications/transportation/utilities	40-49
Trade	50-59
Financial services	60-67
Business and related services	70-79,81,83,87

[1] The "other" engineering category includes a number of smaller fields that are combined in the interest of space. None of these fields individually accounts for more than about 5 percent of the total engineering jobs.

SOURCES: Science Resources Studies Division, National Science Foundation, unpublished tabulations; and Bureau of Labor Statistics, unpublished tabulations from the Occupation Employment Statistics Survey.

See figures 3-1, 3-2, 3-3, 3-4, and 3-5, and figures O-8, O-9, and O-10 in Overview. *Science & Engineering Indicators – 1991*

Appendix table 3-2.

Scientists and engineers employed in R&D in manufacturing industries: 1989

	Scientists in R&D					Engineers in R&D							
	Total	Life	Math	Physical	Computer specialists	Total	Aeronautical/ astronautical	Chemical	Civil	Electrical/ electronic	Industrial	Mechanical	Other
	Thousands												
Total manufacturing	37.8	11.5	0.6	21.3	4.4	77.7	5.6	6.5	0.1	32.6	1.7	9.4	21.8
Transportation equipment	2.0	0	0.3	0	1.7	19.7	5.6	0.2	0	0.5	0.5	1.3	11.6
Machinery, except electrical	0.5	0	0	0	0.5	16.4	0	0	0	10.7	0.3	2.7	2.7
Electrical/electronic equipment	0.6	0	0	0.3	0.3	13.8	0	0.2	0	11.1	0.1	1.1	1.3
Instruments and related products	2.0	0.6	0	0.6	0.7	12.9	0	0.3	0	9.6	0.3	1.0	1.7
Chemicals and allied products	27.8	10.5	0.2	16.2	0.9	7.0	0	4.1	0	0.3	0.2	0.6	1.8
Other	4.9	0.4	0.1	4.2	0.3	7.9	0	1.7	0.1	0.4	0.3	1.9	3.5

SOURCES: Science Resources Studies Division, National Science Foundation, *Total and R&D Scientists, Engineers, and Technicians in Manufacturing Industries: 1989* (Washington, DC:NSF).

See figure 3-6.

Science & Engineering Indicators – 1991

Appendix table 3-3.

Number of 1988 and 1989 science and engineering bachelors degree recipients, by field of degree and graduate school status: 1990

Field of degree	Total	Graduate school status				
		Full-time student	Part-time student	Non-student	Other	No report
Total science and engineering	643,200	127,100	68,800	439,200	7,400	800
Total sciences	494,500	110,000	50,800	327,000	6,200	500
Physical	29,400	11,600	2,600	15,100	100	*
Mathematics	35,200	6,500	3,900	24,300	500	*
Computer	69,300	4,100	6,600	57,900	400	300
Environmental	7,300	2,200	700	4,400	*	*
Life	111,200	35,600	10,400	64,100	1,000	*
Psychology	85,700	17,900	12,000	54,300	1,200	200
Social	156,400	32,000	14,500	106,900	3,000	*
Total engineering	148,700	17,100	18,000	112,200	1,200	300
Aeronautical/astronautical	6,700	800	700	5,200	*	*
Chemical	7,700	1,100	700	5,700	*	*
Civil	15,200	1,500	1,200	12,300	100	*
Electrical/electronic	55,500	5,900	8,100	40,800	600	200
Industrial	12,300	600	1,700	9,900	100	*
Materials	1,800	400	100	1,200	*	*
Mechanical	30,000	3,200	3,100	23,300	300	100
Mining	1,100	300	*	800	*	*
Nuclear	900	200	200	500	*	*
Petroleum	1,200	200	100	900	*	*
Other	16,500	2,800	2,000	11,600	100	100

* = too few cases to report

NOTE: Details may not sum to totals because of rounding.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-8.

Appendix table 3-4.
Number of 1988 and 1989 science and engineering masters degree recipients, by field of degree and graduate school status: 1990

		Graduate school status				
Field of degree	Total	Full-time student	Part-time student	Non-student	Other	No report
Total science and engineering	136,600	31,100	10,300	94,400	800	100
Total sciences	93,700	23,600	6,700	63,100	300	100
Physical	9,200	3,800	500	4,700	100	*
Mathematics/statistics	10,600	1,900	800	7,800	*	*
Computer	22,200	2,100	1,500	18,500	*	*
Environmental	5,200	1,100	300	3,800	100	*
Life	19,300	6,800	1,200	11,200	100	*
Psychology	7,300	2,500	800	3,900	*	*
Social	19,900	5,200	1,500	13,100	100	*
Total engineering	42,900	7,500	3,600	31,300	500	*
Aeronautical/astronautical	1,800	400	100	1,300	*	*
Chemical	2,100	600	100	1,400	*	*
Civil	4,700	500	300	3,900	100	*
Electrical/electronic	13,800	2,600	1,700	9,100	300	*
Industrial	2,600	200	100	2,200	*	*
Materials	1,700	600	100	1,000	*	*
Mechanical	8,000	1,200	800	6,000	*	*
Mining	500	100	*	400	*	*
Nuclear	500	200	*	200	*	*
Petroleum	400	100	*	300	*	*
Other	6,700	900	400	5,400	*	*

* = too few cases to report

NOTE: Details may not sum to totals because of rounding.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-8. *Science & Engineering Indicators – 1991*

Appendix table 3-5.

Median annual salaries of 1988 and 1989 science and engineering (S&E) bachelors degree recipients, by field of degree, gender, and race/ethnicity: 1990

Field of degree	Total	Male	Female	White	Black	Asian	Native American	Hispanic[1]
Total science and engineering	$26,000	$29,500	$21,600	$26,100	$24,000	$30,000	$21,900	$25,100
Total sciences	23,000	25,100	20,100	23,000	22,200	27,900	*	21,100
Physical	25,100	26,500	24,900	25,000	*	*	*	24,000
Mathematics/statistics	23,600	24,000	23,000	24,000	*	*	*	*
Computer	30,100	30,600	30,000	30,100	28,000	33,200	*	30,000
Environmental	23,700	24,000	22,900	23,600	*	*	*	*
Life	21,000	23,000	19,600	21,000	20,100	*	*	*
Psychology	18,600	21,300	18,000	18,600	*	*	*	*
Social	21,900	23,900	20,100	21,500	21,900	*	*	*
Total engineering	33,000	33,000	33,800	33,300	32,500	32,800	*	32,200
Aeronautical/astronautical	34,800	34,400	*	34,900	*	*	*	*
Chemical	35,100	35,100	35,100	35,200	*	*	*	*
Civil	30,100	30,100	31,100	30,000	*	33,600	*	32,900
Electrical/electronic	34,000	34,000	33,900	34,300	32,900	33,300	*	*
Industrial	31,100	30,600	32,700	31,500	27,000	*	*	28,000
Materials	33,200	33,800	31,600	32,900	*	*	*	*
Mechanical	34,000	33,800	35,000	34,000	*	*	*	*
Mining	30,100	31,000	*	31,000	*	*	*	*
Nuclear	33,300	34,000	31,600	33,000	*	*	*	*
Petroleum	36,600	36,500	38,700	36,600	*	*	*	*
Other	30,000	30,000	30,100	30,100	*	*	*	*

* = no median was computed for groups with fewer than 20 individuals reporting salary

NOTES: Median salaries were computed only for full-time employed civilians. Data exclude full-time graduate students.

[1] Includes members of all racial groups.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See text table 3-1.

Appendix table 3-6.

Median annual salaries of 1988 and 1989 science and engineering (S&E) masters degree recipients, by field of degree, gender, and race/ethnicity: 1990

Field of degree	Total	Male	Female	White	Black	Asian	Native American	Hispanic[1]
Total science and engineering	$37,000	$39,000	$32,800	$37,500	$35,000	$35,900	*	$36,100
Total sciences	33,800	35,400	31,200	34,000	30,100	33,000	*	29,000
Physical	34,900	36,000	31,100	35,900	*	32,100	*	*
Mathematics/statistics	32,800	35,000	30,000	32,800	*	*	*	*
Computer	42,100	42,900	40,100	43,900	*	36,000	*	*
Environmental	33,800	35,000	31,800	34,300	*	*	*	*
Life	26,900	26,900	26,600	26,900	*	*	*	*
Psychology	32,000	36,900	32,000	32,100	*	*	*	*
Social	31,000	30,000	31,200	31,100	*	*	*	*
Total engineering	41,400	42,000	40,100	42,100	41,900	39,100	*	40,100
Aeronautical/astronautical	46,500	46,500	*	46,500	*	*	*	*
Chemical	40,200	40,600	38,100	41,000	*	39,100	*	*
Civil	35,200	35,200	35,600	35,900	*	30,800	*	*
Electrical/electronic	46,500	46,700	*	47,900	*	41,000	*	*
Industrial	40,300	40,200	40,400	42,000	*	*	*	*
Materials	41,300	40,400	42,200	41,400	*	40,100	*	*
Mechanical	42,100	42,100	*	42,100	*	*	*	*
Mining	37,300	37,500	*	37,300	*	*	*	*
Nuclear	40,200	40,100	*	40,400	*	*	*	*
Petroleum	40,800	41,100	*	40,900	*	*	*	*
Other	39,000	39,900	37,000	39,000	*	40,000	*	*

* = no median was computed for groups with fewer than 20 individuals reporting salary

NOTES: Median salaries were computed only for full-time employed civilians. Data exclude full-time graduate students.

[1] Includes members of all racial groups.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See text table 3-1.

Appendix table 3-7.

Selected employment characteristics of 1988 and 1989 science and engineering bachelors and masters degree recipients, by field of degree and gender: 1990

(page 1 of 2)

Field of degree and gender	Labor force participation rate		Unemployment rate		In-field employment rate		S&E employment rate	
	Bachelors	Masters	Bachelors	Masters	Bachelors	Masters	Bachelors	Masters
TOTAL SCIENCE AND ENGINEERING	97.4	97.1	3.4	1.8	37.8	59.0	62.0	89.3
Male	98.2	98.5	3.5	1.5	42.7	57.6	NA	NA
Female	96.1	93.9	3.3	2.7	29.9	62.4	NA	NA
Total sciences	96.9	96.9	3.7	1.9	33.2	59.6	52.5	85.2
Male	97.7	98.8	4.0	1.5	38.0	57.1	NA	NA
Female	95.9	94.0	3.4	2.6	27.7	63.7	NA	NA
Physical	97.0	97.9	5.0	2.1	35.6	43.4	84.8	94.8
Male	97.3	98.5	6.0	2.1	33.9	41.7	NA	NA
Female	96.5	*	2.8	*	39.1	*	NA	NA
Mathematics/statistics	96.7	98.1	4.1	1.1	39.6	57.4	74.0	87.8
Male	98.7	99.6	3.1	1.5	31.7	53.3	NA	NA
Female	94.8	95.9	5.2	0.5	47.9	63.1	NA	NA
Computer	98.3	98.2	2.5	1.5	81.5	77.2	87.9	91.8
Male	98.9	99.3	2.4	0.8	79.7	73.0	NA	NA
Female	96.7	95.3	2.6	3.2	86.5	88.8	NA	NA
Environmental	97.2	99.8	4.8	2.7	56.1	69.4	84.6	100.0
Male	97.2	99.7	4.5	2.7	57.3	71.5	NA	NA
Female	*	*	*	*	*	*	NA	NA
Life	96.0	96.5	4.6	2.1	38.4	59.0	64.8	90.4
Male	97.8	98.0	4.3	2.1	40.4	52.5	NA	NA
Female	94.3	95.0	4.8	2.1	36.5	65.9	NA	NA
Psychology	96.1	97.6	2.9	3.6	9.9	48.1	29.5	71.9
Male	97.4	100.0	6.9	2.5	9.4	41.0	NA	NA
Female	95.5	96.3	1.0	4.2	10.1	52.3	NA	NA
Social	97.1	93.4	4.0	2.1	14.1	43.5	28.0	68.0
Male	96.9	97.5	3.8	1.2	16.6	38.9	NA	NA
Female	97.4	88.5	4.2	3.3	11.2	49.5	NA	NA
Total engineering	98.9	97.5	2.7	1.7	50.7	57.8	90.8	98.2
Male	99.0	98.1	2.8	1.5	50.9	58.2	NA	NA
Female	98.0	93.1	2.1	3.2	49.8	54.5	NA	NA
Aeronautical/astronautical	100.0	*	2.5	*	48.9	*	82.3	93.8
Male	100.0	*	2.7	*	46.7	*	NA	NA
Female	*	*	*	*	*	*	NA	NA
Chemical	95.1	*	2.8	*	49.6	*	98.5	NA
Male	93.2	*	4.0	*	51.8	*	NA	NA
Female	99.2	*	0.2	*	45.2	*	NA	NA
Civil	98.6	98.1	2.0	1.4	71.1	69.1	92.9	NA
Male	99.3	98.9	2.1	1.6	71.1	70.8	NA	NA
Female	94.8	*	0.9	*	71.3	*	NA	NA
Electrical/electronic	99.3	95.8	2.6	1.5	53.3	57.7	92.0	NA
Male	99.4	96.9	2.6	0.8	53.8	58.6	NA	NA
Female	98.7	*	3.2	*	49.5	*	NA	NA

(continued)

Appendix table 3-7.

Selected employment characteristics of 1988 and 1989 science and engineering bachelors and masters degree recipients, by field of degree and gender: 1990

(page 2 of 2)

	Labor force participation rate		Unemployment rate		In-field employment rate		S&E employment rate	
Field of degree and gender	Bachelors	Masters	Bachelors	Masters	Bachelors	Masters	Bachelors	Masters
Industrial	98.9	99.1	4.5	5.9	42.2	26.5	85.2	79.2
Male	99.4	99.0	5.3	6.3	41.9	27.1	NA	NA
Female	96.9	*	1.5	*	43.5	*	NA	NA
Materials	*	*	*	*	*	*	NA	NA
Male	*	*	*	*	*	*	NA	NA
Female	*	*	*	*	*	*	NA	NA
Mechanical	98.7	99.5	3.0	0.8	44.3	60.4	91.5	94.7
Male	98.9	99.7	2.8	0.8	43.3	61.1	NA	NA
Female	97.1	*	4.4	*	52.2	*	NA	*
Mining	*	*	*	*	*	*	NA	NA
Male	*	*	*	*	*	*	NA	NA
Female	*	*	*	*	*	*	NA	NA
Nuclear	*	*	*	*	*	*	NA	NA
Male	*	*	*	*	*	*	NA	NA
Female	*	*	*	*	*	*	NA	NA
Petroleum	*	*	*	*	*	*	NA	NA
Male	*	*	*	*	*	*	NA	NA
Female	*	*	*	*	*	*	NA	NA
Other	99.0	97.4	1.4	1.6	38.6	53.5	84.1	98.3
Male	98.9	97.4	1.6	1.6	38.6	48.7	NA	NA
Female	99.4	*	0.6	*	38.7	*	NA	NA

* = no rate was computed for groups with fewer than 1,500 individuals in labor force; NA = not available

NOTE: Data exclude full-time graduate students.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-8 and text table 3-2.

Appendix table 3-8.
Number of 1988 and 1989 science and engineering bachelors degree recipients, by field of degree and primary work activity: 1990

		Primary work activity													
		Research and development				Management/administration									
Field of degree	Total employed	Total	Basic research	Applied research	Devlopment	Total	Of R&D	Of non-R&D	Teaching	Prod./ inspection	Reporting/ stat. work/ computing	Sales	Professional services	Other	No report
Total science and engineering	485,400	89,200	9,300	19,100	60,800	70,700	11,500	59,200	47,500	68,200	73,700	46,400	8,100	77,600	4,200
Total sciences	358,800	45,500	8,500	15,200	21,800	56,000	8,400	47,700	45,300	37,100	61,700	41,70	7,900	60,300	3,300
Physical	16,400	4,800	900	1,700	2,300	1,600	200	1,500	2,000	3,100	1,40	1,100	100	2,200	100
Mathematics/statistics	26,600	2,000	300	500	1,200	2,300	500	1,800	7,700	2,000	6,600	2,200	*	3,600	100
Computer	62,500	13,500	200	800	12,500	4,700	800	3,900	1,300	5,000	28,700	1,300	200	7,100	600
Environmental	4,700	700	200	500	*	400	*	400	300	1,100	500	200	*	1,400	*
Life	69,300	15,000	5,500	6,300	3,300	9,200	1,600	7,700	8,100	13,400	3,300	5,600	2,300	11,300	1,000
Psychology	63,300	3,600	1,000	1,900	800	11,500	1,200	10,200	12,900	3,800	5,300	8,100	3,600	13,900	600
Social	116,000	5,900	500	3,600	1,600	26,300	4,000	22,200	12,900	8,700	15,900	23,100	1,600	20,700	900
Total engineering	126,700	43,700	800	3,900	39,000	14,600	3,100	11,500	2,200	31,000	12,000	4,700	200	17,300	900
Aeronautical/astronautical	5,800	2,100	100	300	1,800	500	100	400	300	1,100	300	100	*	1,500	*
Civil	13,200	2,500	*	200	2,300	2,200	100	2,100	100	3,300	1,000	200	*	3,600	300
Electrical/electronic	47,900	18,900	200	1,700	17,000	5,300	1,700	3,500	500	11,200	5,700	1,700	*	4,200	400
Industrial	11,100	1,800	*	200	1,600	1,900	300	1,500	100	3,500	1,400	700	100	1,400	100
Mechanical	25,600	11,100	100	700	10,300	2,000	100	1,900	600	6,100	1,500	1,100	*	3,100	*
Other	23,100	7,300	300	800	6,000	2,700	800	2,100	600	5,800	2,100	900	*	3,500	*

* = too few cases to report

NOTES: Details may not sum to totals because of rounding. Data exclude full-time graduate students.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-10.

Science & Engineering Indicators – 1991

Appendix table 3-9.

Number of 1988 and 1989 science and engineering masters degree recipients, by field of degree and primary work activity: 1990

Field of degree	Total employed	Primary work activity													
		Research and development				Management/administration									
		Total	Basic research	Applied research	Devlopment	Total	Of R&D	Of non-R&D	Teaching	Prod./ inspection	Reporting/ stat. work/ computing	Sales	Professional services	Other	No report
Total science and engineering	100,600	34,000	3,100	8,000	22,800	15,100	5,000	10,100	12,200	7,600	16,100	2,200	1,300	11,900	200
Total sciences	66,700	16,400	2,600	5,400	8,500	10,800	3,000	7,800	11,400	3,900	13,200	1,700	1,200	8,000	100
Physical	5,200	2,200	500	800	900	300	100	200	1,200	600	400	*	*	400	*
Mathematics/statistics	8,400	1,300	100	500	700	1,000	300	700	3,400	400	1,700	*	*	500	*
Computer	19,400	6,000	100	700	5,200	3,300	1,500	1,800	800	800	6,900	300	*	1,300	*
Environmental	4,000	1,100	200	600	300	500	100	300	200	600	600	*	*	1,000	*
Life	11,800	3,800	1,200	1,800	900	1,600	600	1,100	2,400	900	900	500	300	1,200	*
Psychology	4,500	400	*	100	300	900	100	800	1,200	100	400	*	800	800	*
Social	13,400	1,500	300	1,000	200	3,200	300	2,900	2,100	500	2,200	800	*	3,000	*
Total engineering	33,900	17,600	600	2,700	14,300	4,300	2,000	2,300	900	3,800	2,900	600	*	3,900	100
Aeronautical/astronautical	1,400	900	*	300	600	200	100	100	*	*	100	*	*	100	*
Civil	4,100	1,200	*	200	1,000	600	100	500	100	500	400	100	*	1,300	*
Electrical/electronic	10,500	6,600	200	600	5,800	1,000	800	200	300	1,100	1,000	200	*	400	*
Industrial	2,200	500	*	100	300	500	100	400	*	500	200	100	*	400	*
Mechanical	6,700	4,500	100	500	3,900	600	400	300	200	600	400	*	*	300	*
Other	9,000	3,900	200	1,000	2,700	1,400	500	800	200	1,000	800	100	*	1,300	*

* = too few cases to report

NOTES: Details may not sum to totals because of rounding. Data exclude full-time graduate students.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-10.

Science & Engineering Indicators – 1991

Appendix table 3-10.

Number of 1988 and 1989 science and engineering bachelors degree recipients, by field of degree, gender, and type of employer: 1990

(page 1 of 3)

		Type of employer										
		Business and industry			Educational institution							
Field of degree and gender	Total employed	Total	Industry	Self-employed	Total	4-year college/ univ.	Other	Non-profit org.	Federal Gov't	State/ local gov't	Other	No report
TOTAL SCIENCE & ENGINEERING	485,400	313,000	301,600	11,300	47,300	15,800	31,600	24,400	20,300	26,900	51,400	2,100
Male	299,000	213,200	203,700	9,500	20,400	8,000	12,400	6,700	12,900	15,800	28,800	1,300
Female	186,400	99,800	98,000	1,900	26,900	7,700	19,200	17,700	7,400	11,100	22,600	800
Total sciences	358,800	214,000	204,500	9,600	44,800	14,100	30,700	23,300	12,400	21,100	41,400	1,700
Male	191,100	128,800	121,000	7,800	18,300	6,700	11,600	5,800	6,400	11,000	19,900	900
Female	167,700	85,200	83,500	1,700	26,500	7,300	19,100	17,400	6,000	10,100	21,500	800
Physical	16,400	10,100	10,000	100	3,100	800	2,200	400	500	600	1,700	100
Male	11,100	6,700	6,600	100	2,000	700	1,300	300	300	400	1,400	100
Female	5,300	3,400	3,400	*	1,100	200	900	100	200	200	300	*
Mathematics/statistics	26,600	14,400	14,200	200	7,900	1,100	6,800	800	700	500	2,300	100
Male	13,700	8,100	7,900	100	3,200	800	2,400	300	300	300	1,500	*
Female	12,900	6,300	6,300	*	4,700	300	4,400	600	400	100	800	100
Computer	62,500	50,700	49,700	1,000	3,900	2,500	1,400	700	1,600	1,700	3,300	600
Male	45,800	37,700	36,700	1,000	2,300	1,500	800	500	1,000	1,100	2,700	600
Female	16,700	13,100	13,000	*	1,600	1,000	700	200	600	600	700	*
Environmental	4,700	3,000	2,900	100	300	200	100	*	300	300	800	*
Male	3,400	2,100	2,100	*	200	200	*	*	200	200	700	*
Female	1,300	900	800	*	100	*	100	*	100	100	100	*
Life	69,300	34,600	31,800	2,800	11,400	3,900	7,500	3,500	2,600	4,700	12,100	300
Male	34,500	19,400	17,200	2,200	5,200	1,900	3,300	1,300	1,500	2,200	5,000	*
Female	34,700	15,300	14,700	600	6,200	2,000	4,200	2,200	1,200	2,500	7,100	200
Psychology	63,300	28,800	27,600	1,200	7,200	1,900	5,300	11,900	1,200	5,100	8,900	200
Male	19,200	12,100	11,200	800	900	200	700	2,200	200	1,400	2,500	*
Female	44,000	16,700	16,400	400	6,300	1,700	4,600	9,700	1,000	3,700	6,400	200
Social	116,000	72,500	68,200	4,200	10,900	3,500	7,400	5,900	5,500	8,400	12,300	500
Male	63,300	42,900	39,300	3,600	4,500	1,400	3,100	1,300	3,000	5,400	6,100	200
Female	52,700	29,600	29,000	600	6,400	2,100	4,300	4,600	2,500	2,900	6,200	300

(continued)

Appendix table 3-10.

Number of 1988 and 1989 science and engineering bachelors degree recipients, by field of degree, gender, and type of employer: 1990

(page 2 of 3)

Field of degree and gender	Total employed	Type of employer										
		Business and industry			Educational institution							
		Total	Industry	Self-employed	Total	4-year college/ univ.	Other	Non-profit org.	Federal Gov't	State/ local gov't	Other	No report
Total engineering	126,700	98,900	97,200	1,800	2,600	1,700	800	1,100	7,900	5,800	10,000	400
Male	107,900	84,300	82,700	1,600	2,100	1,300	800	900	6,500	4,800	8,900	400
Female	18,800	14,600	14,500	100	400	400	*	300	1,400	1,000	1,100	*
Aeronautical/astronautical	5,800	3,200	3,200	100	100	100	*	*	800	*	1,600	*
Male	5,200	2,900	2,900	100	100	100	*	*	700	*	1,400	*
Female	600	300	300	*	*	*	*	*	100	*	200	*
Chemical	6,000	5,200	5,200	*	100	100	*	*	300	200	100	*
Male	4,000	3,500	3,500	*	100	100	*	*	200	100	100	*
Female	2,000	1,700	1,700	*	*	*	*	*	200	100	*	*
Civil	13,200	8,600	8,300	300	100	100	*	100	500	2,900	900	100
Male	11,300	7,300	7,000	300	100	100	*	100	400	2,400	800	100
Female	1,900	1,300	1,300	*	*	*	*	*	100	500	100	*
Electrical/electronic	47,900	38,600	37,800	800	1,300	900	300	700	3,400	1,300	2,400	300
Male	42,400	34,300	33,600	700	1,000	700	300	500	2,900	1,200	2,200	300
Female	5,500	4,300	4,200	100	200	200	*	300	500	100	200	*
Industrial	11,100	9,300	9,200	200	100	100	*	*	500	200	900	*
Male	8,700	7,300	7,100	200	100	100	*	*	400	100	800	*
Female	2,400	2,100	2,000	*	*	*	*	*	200	*	100	*
Materials	1,300	1,100	1,100	*	100	*	*	*	100	*	100	*
Male	1,000	800	800	*	*	*	*	*	100	*	100	*
Female	300	200	200	*	*	*	*	*	*	*	*	*
Mechanical	25,600	21,100	20,900	200	300	100	200	200	1,700	600	1,700	*
Male	22,600	18,600	18,300	200	300	100	200	200	1,500	400	1,600	*
Female	3,000	2,500	2,500	*	*	*	*	*	200	100	100	*
Mining	800	700	700	*	*	*	*	*	*	*	*	*
Male	600	600	600	*	*	*	*	*	*	*	*	*
Female	100	100	100	*	*	*	*	*	*	*	*	*

(continued)

Appendix table 3-10.

Number of 1988 and 1989 science and engineering bachelors degree recipients, by field of degree, gender, and type of employer: 1990

(page 3 of 3)

		Type of employer										
		Business and industry			Educational institution							
Field of degree and gender	Total employed	Total	Industry	Self-employed	Total	4-year college/univ.	Other	Non-profit org.	Federal Gov't	State/local gov't	Other	No report
Nuclear	700	300	300	*	*	*	*	*	100	*	300	*
Male	500	300	300	*	*	*	*	*	*	*	200	*
Female	200	*	*	*	*	*	*	*	*	*	100	*
Petroleum	900	800	800	*	*	*	*	*	*	*	*	*
Male	800	700	700	*	*	*	*	*	*	*	*	*
Female	100	100	100	*	*	*	*	*	*	*	*	*
Other	13,400	10,000	9,800	200	500	300	200	*	400	600	1,900	*
Male	10,800	8,000	7,800	200	400	200	200	*	300	500	1,600	*
Female	2,600	2,000	2,000	*	100	100	*	*	100	100	300	*

* = too few cases to report

NOTE: Details may not sum to totals because of rounding. Data exclude full-time graduate students.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-8.

Science & Engineering Indicators – 1991

Appendix table 3-11.

Number of 1988 and 1989 science and engineering masters degree recipients, by field of degree, gender, and type of employer: 1990

(page 1 of 3)

		Type of employer										
		Business and industry			Educational institution							
Field of degree and gender	Total employed	Total	Industry	Self-employed	Total	4-year college/ univ.	Other	Non-profit org.	Federal Gov't	State/ local gov't	Other	No report
TOTAL SCIENCE & ENGINEERING	100,600	60,200	58,000	2,200	16,700	8,100	8,600	2,500	7,800	5,300	7,900	200
Male	71,000	46,700	45,500	1,200	9,200	5,000	4,200	1,200	5,100	3,000	5,700	100
Female	29,600	13,500	12,500	1,000	7,500	3,100	4,400	1,300	2,700	2,300	2,200	100
Total sciences	66,700	33,700	31,900	1,900	15,500	7,100	8,400	2,200	5,400	4,200	5,600	100
Male	41,300	23,200	22,200	1,000	8,100	4,100	4,100	900	3,200	2,200	3,600	*
Female	25,400	10,500	9,600	900	7,400	3,000	4,400	1,300	2,200	2,000	2,000	*
Physical	5,200	2,800	2,800	*	1,400	600	900	100	300	100	300	*
Male	3,700	2,000	2,000	*	900	500	500	100	300	100	300	*
Female	1,400	800	800	*	500	100	400	*	100	*	*	*
Mathematics/statistics	8,400	3,500	3,400	*	3,700	1,000	2,700	100	200	100	800	*
Male	5,000	2,300	2,300	*	1,700	600	1,000	100	100	100	700	*
Female	3,400	1,200	1,200	*	2,000	300	1,700	*	100	*	100	*
Computer	19,400	15,000	14,700	300	1,400	700	700	300	800	300	1,700	*
Male	14,400	11,000	10,700	300	1,000	500	500	100	600	200	1,400	*
Female	5,100	4,000	4,000	*	400	200	200	200	200	100	200	*
Environmental	4,000	2,500	2,300	100	400	300	100	*	500	300	300	*
Male	2,800	1,900	1,800	100	300	200	100	*	300	100	200	*
Female	1,100	600	500	*	100	100	*	*	200	200	100	*
Life	11,800	3,500	3,200	300	4,100	2,100	2,000	500	1,400	1,200	1,000	*
Male	34,500	19,400	17,200	2,200	5,200	1,900	3,300	1,300	1,500	2,200	5,000	*
Female	34,700	15,300	14,700	600	6,200	2,000	4,200	2,200	1,200	2,500	7,100	200
Psychology	4,500	1,400	1,400	*	1,100	500	600	700	200	300	700	*
Male	1,700	600	600	*	400	200	300	200	200	100	200	*
Female	2,800	800	800	*	700	300	300	500	100	200	500	*
Social	13,400	5,100	4,100	1,000	3,400	1,900	1,500	500	1,800	1,900	800	*
Male	7,700	3,000	2,700	300	1,900	1,000	900	300	1,200	800	400	*
Female	5,800	2,100	1,400	700	1,500	900	600	300	600	1,100	400	*

(continued)

Appendix table 3-11.

Number of 1988 and 1989 science and engineering masters degree recipients, by field of degree, gender, and type of employer: 1990
(page 2 of 3)

Field of degree and gender	Total employed	Type of employer: Business and industry: Total	Business and industry: Industry	Business and industry: Self-employed	Educational institution: Total	Educational institution: 4-year college/univ.	Educational institution: Other	Non-profit org.	Federal Gov't	State/local gov't	Other	No report
Total engineering	33,900	26,500	26,200	300	1,200	1,000	200	300	2,400	1,100	2,300	100
Male	29,700	23,500	23,200	200	1,000	900	100	300	1,900	800	2,100	100
Female	4,200	3,000	2,900	100	200	100	*	*	500	300	200	*
Aeronautical/astronautical	1,400	1,000	1,000	*	*	*	*	100	200	*	100	*
Male	1,400	900	900	*	*	*	*	100	200	*	100	*
Female	*	*	*	*	*	*	*	*	*	*	*	*
Chemical	1,400	1,200	1,200	*	100	100	*	*	*	*	*	*
Male	1,100	1,000	1,000	*	100	100	*	*	*	*	*	*
Female	300	200	200	*	*	*	*	*	*	*	*	*
Civil	4,100	2,800	2,800	*	100	100	*	*	400	500	300	*
Male	3,600	2,600	2,500	*	100	100	*	*	200	400	300	*
Female	500	300	300	*	*	*	*	*	100	100	*	*
Electrical/electronic	10,500	8,700	8,600	100	300	300	*	*	700	100	700	*
Male	9,600	8,000	8,000	*	300	300	*	*	600	*	700	*
Female	900	700	600	100	*	*	*	*	*	100	*	*
Industrial	2,200	1,700	1,700	*	100	100	*	*	200	*	200	*
Male	1,800	1,400	1,400	*	100	100	*	*	100	*	200	*
Female	400	300	300	*	*	*	*	*	100	*	*	*
Materials	1,000	900	900	*	*	*	*	*	*	*	*	*
Male	700	600	600	*	*	*	*	*	*	*	*	*
Female	300	300	300	*	*	*	*	*	*	*	*	*
Mechanical	6,700	5,600	5,500	100	300	300	*	100	400	100	200	*
Male	6,300	5,400	5,300	100	300	300	*	100	300	100	200	*
Female	400	300	300	*	*	*	*	*	100	*	*	*
Mining	400	300	300	*	*	*	*	*	*	*	*	*
Male	300	200	200	*	*	*	*	*	*	*	*	*
Female	100	100	100	*	*	*	*	*	*	*	*	*

(continued)

Appendix table 3-11.

Number of 1988 and 1989 science and engineering masters degree recipients, by field of degree, gender, and type of employer: 1990

(page 3 of 3)

Field of degree and gender	Total employed	Type of employer: Business and industry: Total	Business and industry: Industry	Business and industry: Self-employed	Educational institution: Total	Educational institution: 4-year college/ univ.	Educational institution: Other	Non-profit org.	Federal Gov't	State/ local gov't	Other	No report
Nuclear	300	200	200	*	*	*	*	*	*	*	100	*
Male	200	100	100	*	*	*	*	*	*	*	100	*
Female	*	*	*	*	*	*	*	*	*	*	*	*
Petroleum	300	300	300	*	*	*	*	*	*	*	*	*
Male	300	200	200	*	*	*	*	*	*	*	*	*
Female	*	*	*	*	*	*	*	*	*	*	*	*
Other	5,500	3,800	3,800	100	200	100	100	*	500	300	600	*
Male	4,300	3,000	2,900	100	200	100	100	*	300	300	600	*
Female	1,200	900	800	*	100	*	*	*	200	100	*	*

* = too few cases to report

NOTE: Details may not sum to totals because of rounding. Data exclude full-time graduate students.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF, forthcoming).

See figure 3-8.

Science & Engineering Indicators – 1991

Appendix table 3-12.
Employed doctoral scientists and engineers, by field and gender: 1977-89
(page 1 of 2)

Field and gender	1977	1979	1981	1983	1985	1987	1989
TOTAL SCIENTISTS AND ENGINEERS	285,055	314,257	343,956	369,320	400,358	419,118	448,645
Male	257,465	280,857	302,971	320,494	341,873	352,386	371,483
Female	27,590	33,400	40,985	48,826	58,485	66,732	77,160
Total scientists	240,005	263,915	286,917	307,775	334,505	351,350	373,860
Male	212,696	231,040	246,685	260,025	277,508	286,346	299,015
Female	27,309	32,875	40,232	47,750	56,997	65,004	74,845
Physical	57,531	60,222	63,110	63,986	67,480	68,647	70,209
Male	54,594	57,086	59,346	59,811	62,809	63,163	64,139
Female	2,937	3,136	3,764	4,175	4,671	5,484	6,070
Mathematical	14,609	15,250	15,569	16,379	16,758	16,699	17,611
Male	13,560	14,104	14,259	14,964	15,199	15,074	15,766
Female	1,049	1,146	1,310	1,415	1,559	1,625	1,845
Computer specialists	5,767	6,684	9,064	12,164	14,964	18,571	19,797
Male	5,534	6,318	8,363	10,898	13,345	16,693	17,493
Female	233	366	701	1,266	1,619	1,878	2,304
Environmental	13,001	14,575	15,909	16,467	17,288	17,811	19,787
Male	12,560	13,968	15,054	15,553	16,199	16,510	18,123
Female	441	607	855	914	1,089	1,301	1,664
Life	70,537	78,857	84,912	92,802	101,838	107,378	115,833
Male	61,437	67,528	71,593	76,573	82,146	85,269	89,558
Female	9,100	11,329	13,319	16,229	19,692	22,109	26,275
Psychologists	33,652	37,848	42,829	46,645	52,182	56,378	60,596
Male	26,055	28,690	31,103	32,962	35,573	37,274	38,754
Female	7,597	9,158	11,726	13,683	16,609	19,104	21,842
Social	44,908	50,479	55,524	59,332	63,995	65,866	70,027
Male	38,956	43,346	46,967	49,264	52,237	52,363	55,182
Female	5,952	7,133	8,557	10,068	11,758	13,503	14,845
Total engineers	45,050	50,342	57,039	61,545	65,853	67,768	74,783
Male	44,769	49,817	56,286	60,469	64,365	66,040	72,468
Female	281	525	753	1,076	1,488	1,728	2,315
Aeronautical/astronautical	1,987	2,364	2,519	3,684	3,827	5,005	6,367
Male	1,967	2,340	2,480	3,614	3,732	4,884	6,156
Female	20	24	39	70	95	121	211
Chemical	5,603	6,166	7,146	6,992	7,122	6,923	7,959
Male	5,575	6,117	7,092	6,895	7,021	6,783	7,744
Female	28	49	54	97	101	140	215
Civil	4,066	5,157	6,089	5,317	6,396	6,479	6,951
Male	4,051	5,101	6,003	5,245	6,305	6,316	6,762
Female	15	56	86	72	91	163	189
Electrical/electronic	8,284	8,597	10,630	12,696	14,248	12,601	15,088
Male	8,246	8,528	10,493	12,460	13,901	12,236	14,651
Female	38	69	137	236	347	365	437
Mechanical	4,648	5,245	5,370	5,657	6,594	6,711	7,390
Male	4,629	5,213	5,330	5,603	6,536	6,613	7,287
Female	19	32	40	54	58	98	103

(continued)

Appendix table 3-12.
Employed doctoral scientists and engineers, by field and gender: 1977-89
(page 2 of 2)

Field and gender	1977	1979	1981	1983	1985	1987	1989
Other	20,462	22,813	25,285	27,199	27,666	30,049	31,028
Male	20,301	22,518	24,888	26,652	26,870	29,208	29,868
Female	161	295	397	547	796	841	1,160

NOTE: Details may not sum to totals because of rounding.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317 (Washington, DC: NSF, 1991).

See figures 3-11, 3-12, and 3-15.

Science & Engineering Indicators – 1991

Appendix table 3-13.
Employed doctoral scientists and engineers, by field and race/ethnicity: 1977-89
(page 1 of 2)

Field and racial/ethnic group	1977	1979	1981	1983	1985	1987	1989
TOTAL SCIENTISTS AND ENGINEERS	285,055	314,257	343,953	369,320	400,358	419,118	448,643
White	258,255	284,965	309,123	328,455	355,125	372,985	397,169
Black	2,709	3,227	4,224	4,948	5,716	6,359	7,153
Asian	16,275	22,912	27,350	29,740	34,533	36,397	41,106
Other	7,816	3,153	3,256	6,177	4,984	3,377	3,215
Total scientists	240,005	263,915	286,917	307,775	334,505	351,350	373,860
White	219,636	243,008	261,912	278,722	302,526	319,091	338,040
Black	2,588	3,125	3,954	4,538	5,203	5,704	6,539
Asian	11,229	15,037	18,328	19,259	22,651	23,645	26,522
Other	6,552	2,745	2,723	5,256	4,125	2,910	2,759
Physical	57,531	60,222	63,110	63,986	67,480	68,647	70,209
White	51,963	54,618	56,245	56,521	59,598	60,751	61,594
Black	543	403	579	690	522	620	831
Asian	3,441	4,719	5,769	5,684	6,561	6,788	7,195
Other	1,584	482	517	1,091	799	488	589
Mathematical	14,609	15,250	15,569	16,379	16,758	16,699	17,611
White	13,218	13,729	13,975	14,531	14,921	14,940	15,624
Black	120	144	167	178	166	166	198
Asian	799	1,110	1,155	1,378	1,368	1,482	1,644
Other	472	267	272	292	303	111	145
Computer specialists	5,767	6,684	9,064	12,164	14,964	18,571	19,797
White	5,014	6,059	8,056	11,012	13,064	16,219	17,018
Black	15	4	27	43	85	200	190
Asian	613	561	868	944	1,634	1,838	2,423
Other	125	60	113	165	181	314	166
Environmental	13,001	14,575	15,909	16,467	17,288	17,811	19,787
White	12,125	13,813	14,996	15,476	15,774	16,587	18,165
Black	24	65	34	33	98	222	228
Asian	572	539	744	770	1,133	943	1,338
Other	280	158	135	188	283	59	56
Life	70,537	78,857	84,912	92,802	101,838	107,378	115,833
White	64,243	71,861	77,089	83,378	92,002	96,955	104,295
Black	769	883	1,013	1,142	1,419	1,456	1,633
Asian	3,980	5,417	6,257	6,750	7,412	8,207	9,276
Other	1,545	696	553	1,532	1,005	760	629
Psychologists	33,652	37,848	42,829	46,645	52,182	56,378	60,596
White	31,943	36,480	9,825	44,237	49,508	53,655	57,833
Black	467	594	809	983	1,190	1,266	1,350
Asian	313	412	583	640	756	858	934
Other	929	362	31,612	785	728	599	479
Social	44,908	50,479	55,524	59,332	63,995	65,866	70,027
White	41,130	46,448	50,542	53,567	57,659	59,984	63,511
Black	650	1,032	1,325	1,469	1,723	1,774	2,109
Asian	1,511	2,279	2,952	3,093	3,787	3,529	3,712
Other	1,617	720	705	1,203	826	579	695

(continued)

Appendix table 3-13.

Employed doctoral scientists and engineers, by field and race/ethnicity: 1977-89

(page 2 of 2)

Field and racial/ethnic group	1977	1979	1981	1983	1985	1987	1989
Total engineers	45,050	50,342	57,039	61,545	65,853	67,768	74,783
White	38,619	41,957	47,211	49,733	52,599	53,894	59,129
Black	121	102	270	410	513	655	614
Asian	5,046	7,875	9,022	10,481	11,882	12,752	14,584
Other	1,264	408	536	921	859	467	456
Aeronautical/astronautical	1,987	2,364	2,519	3,684	3,827	5,005	6,367
White	1,793	2,122	2,232	3,128	3,295	4,092	4,786
Black	0	2	10	21	27	34	165
Asian	138	232	269	482	503	869	1,395
Other	56	8	8	53	2	10	21
Chemical	5,603	6,166	7,146	6,992	7,122	6,923	7,959
White	4,674	4,953	5,553	5,384	5,130	4,988	6,008
Black	12	10	37	13	66	72	39
Asian	721	1,200	1,554	1,502	1,923	1,814	1,899
Other	196	3	2	93	3	49	13
Civil	4,066	5,157	6,089	5,317	6,396	6,479	6,951
White	3,255	3,875	4,785	4,190	5,063	5,182	5,554
Black	5	1	24	24	85	23	77
Asian	718	1,204	1,226	1,059	1,182	1,254	1,305
Other	88	77	54	44	66	20	15
Electrical/electronic	8,284	8,597	10,630	12,696	14,248	12,601	15,088
White	7,229	7,252	8,931	10,310	11,386	9,744	11,604
Black	45	15	40	75	90	209	118
Asian	833	1,272	1,552	2,093	2,553	2,525	3,234
Other	177	58	107	218	219	123	132
Mechanical	4,648	5,245	5,370	5,657	6,594	6,711	7,390
White	3,793	4,057	4,313	4,382	5,069	5,124	5,800
Black	5	22	10	91	81	127	14
Asian	771	1,165	1,045	1,157	1,354	1,412	1,497
Other	79	1	2	27	90	48	79
Other	20,462	22,813	25,285	27,199	27,666	30,049	31,028
White	17,875	19,698	21,397	22,339	22,656	24,764	25,377
Black	54	52	149	186	164	190	201
Asian	1,865	2,802	3,376	4,188	4,367	4,878	5,254
Other	668	261	363	486	479	217	196

NOTE: Details may not sum to totals because of rounding.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers: 1989*, NSF 91-317 (Washington, DC: NSF, 1991).

See figure 3-16. *Science & Engineering Indicators – 1991*

Appendix table 3-14.

Employed doctoral scientists and engineers, by field and primary work activity: 1977-89

(page 1 of 4)

Field and primary work activity	1977	1979	1981	1983	1985	1987	1989
TOTAL SCIENTISTS AND ENGINEERS	285,055	314,257	343,956	369,320	400,358	419,118	448,643
Research	79,995	84,678	101,691	104,511	110,539	135,384	145,559
Basic research	43,551	47,908	55,181	57,137	61,451	63,230	67,687
Applied research[1]	36,444	36,770	46,510	47,374	49,088	72,154	77,872
Development	13,188	15,009	18,361	20,277	21,976	18,909	21,042
Management of R&D	30,783	43,084	32,709	31,418	34,938	33,897	35,414
Management other than R&D	29,913	29,230	27,806	30,395	34,694	33,850	38,072
Teaching	90,830	92,242	105,150	108,236	111,717	109,730	112,715
Consulting	6,149	9,012	12,065	12,746	14,164	13,804	16,767
Sales/professional services[1]	15,233	21,126	25,757	29,820	36,496	32,644	36,599
Reporting/statistical work/computing	NA	NA	NA	NA	NA	11,891	25,029
Other	18,964	19,876	20,417	31,917	35,834	29,009	17,446
Total scientists	240,005	263,915	286,917	307,775	334,505	351,350	373,860
Research	69,683	74,739	88,180	89,528	95,556	115,587	123,312
Basic research	41,892	45,953	52,404	54,038	57,833	59,716	64,112
Applied research[1]	27,791	28,786	35,776	35,490	37,723	55,871	59,200
Development	6,349	7,185	8,487	10,514	11,185	9,083	9,348
Management of R&D	22,135	30,565	22,489	20,881	24,003	22,792	24,354
Management other than R&D	24,003	24,915	22,869	25,440	29,242	29,402	33,238
Teaching	82,029	82,909	94,416	96,403	99,237	97,938	99,972
Consulting	4,538	6,415	8,231	8,999	10,459	9,910	11,549
Sales/professional services[1]	14,568	20,029	24,271	28,568	34,252	32,500	36,467
Reporting/statistical work/computing	NA	NA	NA	NA	NA	10,527	20,297
Other	16,700	17,158	17,974	27,442	30,571	23,611	15,323
Physical	57,531	60,222	63,110	63,986	67,480	68,647	70,209
Research	22,271	21,135	26,515	25,569	26,253	30,750	31,846
Basic research	12,168	12,087	13,848	14,049	14,349	13,158	13,047
Applied research[1]	10,103	9,048	12,667	11,520	11,904	17,592	18,799
Development	2,543	2,796	3,075	3,484	3,647	3,779	3,831
Management of R&D	8,464	12,644	8,785	8,793	9,370	8,184	8,493
Management other than R&D	4,718	3,523	3,165	3,052	3,627	2,750	3,549
Teaching	14,724	14,450	15,570	14,652	15,170	15,213	14,492
Consulting	407	761	1,112	925	1,206	1,390	1,245
Sales/professional services[1]	1,088	1,205	1,437	1,641	2,026	531	531
Reporting/statistical work/computing	NA	NA	NA	NA	NA	959	3,993
Other	3,316	3,708	3,451	5,870	6,181	5,091	2,229
Mathematical	14,609	15,250	15,569	16,379	16,758	16,699	17,611
Research	2,912	3,138	2,969	2,913	3,452	3,838	4,241
Basic research	1,830	2,073	1,741	1,767	2,323	2,835	3,090
Applied research[1]	1,082	1,065	1,228	1,146	1,129	1,003	1,151
Development	408	492	395	490	573	161	200
Management of R&D	298	443	282	531	357	307	264
Management other than R&D	1,082	1,281	1,042	965	1,343	1,110	1,094
Teaching	9,088	8,865	9,596	9,701	9,445	9,347	9,758
Consulting	145	369	458	599	473	308	328
Sales/professional services[1]	78	249	300	261	213	22	46
Reporting/statistical work/computing	NA	NA	NA	NA	NA	808	1,213
Other	598	413	527	919	902	798	467

(continued)

Appendix table 3-14.
Employed doctoral scientists and engineers, by field and primary work activity: 1977-89
(page 2 of 4)

Field and primary work activity	1977	1979	1981	1983	1985	1987	1989
Computer specialists	5,767	6,684	9,064	12,164	14,964	18,571	19,797
Research	777	909	1,515	1,508	1,970	3,415	3,658
Basic research	283	435	620	615	1,005	1,391	1,463
Applied research[1]	494	474	895	893	965	2,024	2,195
Development	1,812	2,131	3,008	3,892	4,106	3,067	2,933
Management of R&D	735	971	808	1,114	1,734	2,292	2,368
Management other than R&D	667	681	890	938	1,128	1,348	1,627
Teaching	1,192	1,094	1,546	2,361	2,828	2,809	3,559
Consulting	155	301	554	678	914	825	884
Sales/professional services[1]	65	151	217	375	461	3	37
Reporting/statistical work/computing	NA	NA	NA	NA	NA	3,287	4,161
Other	364	446	526	1,298	1,823	1,525	570
Environmental	13,001	14,575	15,909	16,467	17,288	17,811	19,787
Research	4,674	5,242	6,036	6,399	6,501	7,567	8,477
Basic research	2,499	2,704	3,307	3,287	3,559	3,599	3,924
Applied research[1]	2,175	2,538	2,729	3,112	2,942	3,968	4,553
Development	200	370	286	329	313	141	253
Management of R&D	1,631	2,361	2,380	1,825	2,058	1,937	2,141
Management other than R&D	1,448	1,193	1,166	1,304	1,400	1,647	1,635
Teaching	3,510	2,975	3,606	3,435	3,393	3,418	3,447
Consulting	364	838	1,045	1,198	1,407	1,402	1,785
Sales/professional services[1]	137	216	381	242	315	88	74
Reporting/statistical work/computing	NA	NA	NA	NA	NA	630	1,130
Other	1,037	1,380	1,009	1,735	1,901	981	845
Life	70,537	78,857	84,912	92,802	101,838	107,378	115,833
Research	27,868	31,905	37,962	39,491	42,865	51,701	55,277
Basic research	19,954	23,413	27,223	28,784	30,990	31,225	33,640
Applied research[1]	7,914	8,492	10,739	10,707	11,875	20,476	21,637
Development	817	855	1,049	1,532	1,725	1,418	1,583
Management of R&D	7,340	9,246	6,711	6,165	7,328	7,310	8,036
Management other than R&D	6,206	6,613	5,416	6,806	8,335	8,233	9,405
Teaching	18,992	19,292	21,733	22,452	22,430	21,701	21,998
Consulting	1,037	1,441	1,535	1,981	2,383	2,258	2,657
Sales/professional services[1]	3,017	4,264	5,264	6,223	7,325	6,720	7,057
Reporting/statistical work/computing	NA	NA	NA	NA	NA	1,636	4,830
Other	5,260	5,241	5,242	8,152	9,447	6,401	4,990
Psychologists	33,652	37,848	42,829	46,645	52,182	56,378	60,596
Research	3,705	4,535	4,970	4,704	4,765	6,107	6,637
Basic research	1,937	2,546	2,464	2,344	2,316	2,884	3,290
Applied research[1]	1,768	1,989	2,506	2,360	2,449	3,223	3,347
Development	204	271	404	313	423	364	316
Management of R&D	1,609	1,620	1,060	903	1,043	1,030	898
Management other than R&D	4,297	5,002	4,745	4,705	5,152	5,695	6,106
Teaching	10,805	10,330	12,477	12,708	13,184	13,839	13,455
Consulting	1,481	1,499	2,051	2,084	2,118	1,576	2,239
Sales/professional services[1]	9,573	12,964	15,128	18,488	22,044	24,677	28,090
Reporting/statistical work/computing	NA	NA	NA	NA	NA	597	1,094
Other	1,978	1,627	1,994	2,740	3,453	2,493	1,761

(continued)

Appendix table 3-14.

Employed doctoral scientists and engineers, by field and primary work activity: 1977-89
(page 3 of 4)

Field and primary work activity	1977	1979	1981	1983	1985	1987	1989
Social	44,908	50,479	55,524	59,332	63,995	65,866	70,027
Research	7,476	7,875	8,213	8,944	9,750	12,209	13,176
Basic research	3,221	2,695	3,201	3,192	3,291	4,624	5,658
Applied research[1]	4,255	5,180	5,012	5,752	6,459	7,585	7,518
Development	365	270	270	474	398	153	232
Management of R&D	2,058	3,280	2,463	1,550	2,113	1,732	2,154
Management other than R&D	5,585	6,622	6,445	7,670	8,257	8,619	9,822
Teaching	23,718	25,903	29,888	31,094	32,787	31,611	33,263
Consulting	949	1,206	1,476	1,534	1,958	2,151	2,411
Sales/professional services[1]	610	980	1,544	1,338	1,868	459	632
Reporting/statistical work/computing	NA	NA	NA	NA	NA	2,610	3,876
Other	4,147	4,343	5,225	6,728	6,864	6,322	4,461
Total engineers	45,050	50,342	57,039	61,545	65,853	67,768	74,783
Research	10,312	9,939	13,511	14,983	14,983	19,797	22,247
Basic research	1,659	1,955	2,777	3,099	3,618	3,514	3,575
Applied research[1]	8,653	7,984	10,734	11,884	11,365	16,283	18,672
Development	6,839	7,824	9,874	9,763	10,791	9,826	11,694
Management of R&D	8,648	12,519	10,220	10,537	10,935	11,105	11,060
Management other than R&D	5,910	4,315	4,937	4,955	5,452	4,448	4,834
Teaching	8,801	9,333	10,734	11,833	12,480	11,792	12,743
Consulting	1,611	2,597	3,834	3,747	3,705	3,894	5,218
Sales/professional services[1]	665	1,097	1,486	1,252	2,244	144	132
Reporting/statistical work/computing	NA	NA	NA	NA	NA	1,364	4,732
Other	2,264	2,718	2,443	4,475	5,263	5,398	2,123
Aeronautical/astronautical	1,987	2,364	2,519	3,684	3,827	5,005	6,367
Research	586	733	763	994	1,045	1,327	1,847
Basic research	104	293	175	273	300	231	358
Applied research[1]	482	440	588	721	745	1,096	1,489
Development	324	521	314	806	805	1,025	1,382
Management of R&D	454	574	620	798	931	1,446	1,408
Management other than R&D	195	86	218	156	176	224	170
Teaching	336	310	387	517	335	436	631
Consulting	0	0	40	138	127	207	365
Sales/professional services[1]	25	61	84	79	125	51	0
Reporting/statistical work/computing	NA	NA	NA	NA	NA	114	242
Other	67	79	93	196	283	175	322
Chemical	5,603	6,166	7,146	6,992	7,122	6,923	7,959
Research	1,187	1,035	2,125	2,054	1,995	2,503	3,446
Basic research	199	175	278	374	446	488	491
Applied research[1]	988	860	1,847	1,680	1,549	2,015	2,955
Development	865	1,122	1,480	914	1,161	818	1,255
Management of R&D	1,301	1,809	1,192	1,110	1,214	968	894
Management other than R&D	903	662	432	587	542	390	428
Teaching	713	620	963	1,078	904	1,110	843
Consulting	182	217	387	227	225	195	375
Sales/professional services[1]	147	124	212	185	425	0	0
Reporting/statistical work/computing	NA	NA	NA	NA	NA	103	471
Other	305	577	355	837	656	836	247

(continued)

Appendix table 3-14.
Employed doctoral scientists and engineers, by field and primary work activity: 1977-89
(page 4 of 4)

Field and primary work activity	1977	1979	1981	1983	1985	1987	1989
Civil	4,066	5,157	6,089	5,317	6,396	6,479	6,951
Research	565	705	704	580	822	1,234	1,213
Basic research	55	36	134	189	298	276	300
Applied research[1]	510	669	570	391	524	958	913
Development	285	252	514	318	530	224	236
Management of R&D	377	432	443	180	470	228	231
Management other than R&D	710	624	770	598	668	781	755
Teaching	1,470	1,633	2,164	2,132	2,231	2,369	2,439
Consulting	347	1,073	983	934	788	871	1,461
Sales/professional services[1]	60	165	233	113	318	8	78
Reporting/statistical work/computing	NA	NA	NA	NA	NA	60	307
Other	252	273	278	462	569	704	231
Electrical/electronic	8,284	8,597	10,630	12,696	14,248	12,601	15,088
Research	1,418	1,327	1,976	2,455	2,344	2,737	3,451
Basic research	218	100	273	330	493	494	743
Applied research[1]	1,200	1,227	1,703	2,125	1,851	2,243	2,708
Development	1,832	1,454	2,429	2,551	2,943	2,966	3,285
Management of R&D	1,631	2,534	2,128	2,817	2,899	2,197	3,102
Management other than R&D	959	826	836	1,144	1,273	760	814
Teaching	1,897	1,842	2,313	2,447	3,028	2,153	2,808
Consulting	84	123	377	380	422	468	424
Sales/professional services[1]	106	186	242	247	423	26	0
Reporting/statistical work/computing	NA	NA	NA	NA	NA	224	886
Other	357	305	329	655	916	1,070	318
Mechanical	4,648	5,245	5,370	5,657	6,594	6,711	7,390
Research	931	778	1,219	836	1,214	1,850	1,964
Basic research	134	172	344	156	376	244	251
Applied research[1]	797	606	875	680	838	1,606	1,713
Development	598	853	1,015	1,055	1,264	838	1,199
Management of R&D	826	1,023	660	597	896	697	707
Management other than R&D	579	392	379	491	529	411	402
Teaching	1,267	1,582	1,501	1,867	2,025	2,109	2,387
Consulting	164	364	378	342	340	330	304
Sales/professional services[1]	61	178	132	65	113	0	41
Reporting/statistical work/computing	NA	NA	NA	NA	NA	88	224
Other	222	75	86	404	213	388	162
Other engineers	20,462	22,813	25,285	27,199	27,666	30,049	31,028
Research	5,625	5,361	6,724	8,064	7,563	10,146	10,326
Basic research	949	1,179	1,573	1,777	1,705	1,781	1,432
Applied research[1]	4,676	4,182	5,151	6,287	5,858	8,365	8,894
Development	2,935	3,622	4,122	4,119	4,088	3,955	4,337
Management of R&D	4,059	6,147	5,177	5,035	4,525	5,569	4,718
Management other than R&D	2,564	1,725	2,302	1,979	2,264	1,882	2,265
Teaching	3,118	3,346	3,406	3,792	3,957	3,615	3,635
Consulting	834	820	1,669	1,726	1,803	1,823	2,289
Sales/professional services[1]	266	383	583	563	840	59	13
Reporting/statistical work/computing	NA	NA	NA	NA	NA	775	2,602
Other	1,061	1,409	1,302	1,921	2,626	2,225	843

NA = not available

NOTE: Details may not sum to totals because of rounding.

[1] In 1987, sales/professional services was redefined to include only professional services; sales data from 1987 on are included with "other." In 1987, applied research was redefined. Data from 1987 on reflect this change.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989,* NSF 91-317 (Washington, DC: NSF, 1991).

See figure 3-13.

Science & Engineering Indicators – 1991

Appendix table 3-15.

Employed doctoral scientists and engineers, by field and type of employer: 1977-89

(page 1 of 3)

Field and type of employer	1977	1979	1981	1983	1985	1987	1989
TOTAL SCIENTISTS AND ENGINEERS	285,055	314,257	343,956	369,320	400,358	419,118	448,643
Business and industry	71,562	82,858	99,126	113,463	125,767	131,699	145,148
Educational institution	163,768	174,483	187,011	196,050	211,611	218,697	230,932
Federal Government	21,389	23,946	25,124	25,793	26,337	27,532	29,242
State and local government	5,308	6,123	6,558	7,717	8,217	9,223	10,397
Nonprofit organization	10,195	12,454	12,601	11,894	13,617	15,464	16,150
Other	12,833	14,393	13,536	14,403	14,809	16,503	16,774
Total scientists	240,005	263,915	286,917	307,775	334,505	351,350	373,860
Business and industry	48,694	56,341	67,338	78,963	87,909	94,552	103,189
Educational institution	147,851	157,409	168,969	175,730	189,914	194,987	205,810
Federal Government	17,870	20,375	21,321	21,950	22,530	23,926	24,696
State and local government	4,924	5,882	6,201	7,334	7,855	8,697	9,858
Nonprofit organization	8,644	10,438	10,263	9,973	11,903	13,290	13,961
Other	12,022	13,470	12,825	13,825	14,394	15,898	16,346
Physical	57,531	60,222	63,110	63,986	67,480	68,647	70,209
Business and industry	23,006	24,989	27,409	28,748	30,281	30,741	32,042
Educational institution	27,118	27,300	28,225	27,931	29,700	30,310	30,276
Federal Government	3,945	4,598	4,342	4,307	4,044	4,322	4,602
State and local government	276	279	358	246	344	448	424
Nonprofit organization	2,042	1,985	2,093	1,751	2,286	2,167	2,095
Other	1,144	1,071	683	1,003	825	659	770
Mathematical	14,609	15,250	15,569	16,379	16,758	16,699	17,611
Business and industry	1,312	1,469	1,616	2,027	1,911	1,838	2,105
Educational institution	12,223	12,550	12,719	13,244	13,560	13,674	14,300
Federal Government	604	817	852	790	853	848	786
State and local government	51	51	2	21	34	26	63
Nonprofit organization	261	294	263	211	293	151	285
Other	158	69	117	86	107	162	72
Computer specialists	5,767	6,684	9,064	12,164	14,964	18,571	19,797
Business and industry	3,058	3,669	5,228	6,819	8,351	11,383	11,483
Educational institution	2,128	2,404	3,010	4,031	5,288	5,558	6,553
Federal Government	251	336	355	490	692	797	820
State and local government	81	7	152	336	248	258	308
Nonprofit organization	159	163	276	345	329	444	518
Other	90	105	43	143	56	131	115
Environmental	13,001	14,575	15,909	16,467	17,288	17,811	19,787
Business and industry	3,103	4,246	4,705	5,154	5,254	5,168	6,266
Educational institution	6,285	6,146	6,741	6,682	7,222	7,483	8,001
Federal Government	2,417	2,716	3,075	3,102	3,309	3,363	3,264
State and local government	506	655	604	819	666	913	1,131
Nonprofit organization	520	614	623	555	678	702	894
Other	170	198	161	155	159	182	231
Life	70,537	78,857	84,912	92,802	101,838	107,378	115,833
Business and industry	9,734	11,145	13,123	16,444	19,165	20,455	23,572
Educational institution	46,865	51,673	55,762	58,906	63,595	66,415	70,479
Federal Government	6,372	7,167	7,225	7,771	7,962	8,709	9,132
State and local government	1,452	1,551	1,670	1,710	2,166	1,944	2,743
Nonprofit organization	2,401	2,970	3,150	3,258	3,884	4,256	4,267
Other	3,713	4,351	3,982	4,713	5,066	5,599	5,640

(continued)

Appendix table 3-15.
Employed doctoral scientists and engineers, by field and type of employer: 1977-89
(page 2 of 3)

Field and type of employer	1977	1979	1981	1983	1985	1987	1989
Psychologists	33,652	37,848	42,829	46,645	52,182	56,378	60,596
Business and industry	5,528	7,077	10,122	13,020	15,530	17,381	19,899
Educational institution	18,512	19,846	21,675	22,182	24,893	25,369	26,425
Federal Government	1,220	1,080	1,211	1,191	1,049	1,388	1,426
State and local government	1,336	1,680	1,715	2,148	1,916	2,197	2,211
Nonprofit organization	1,272	1,725	1,679	1,773	2,084	2,501	2,697
Other	5,784	6,440	6,427	6,331	6,710	7,542	7,938
Social	44,908	50,479	55,524	59,332	63,995	65,866	70,027
Business and industry	2,953	3,746	5,135	6,751	7,417	7,586	7,822
Educational institution	34,720	37,490	40,837	42,754	45,656	46,178	49,776
Federal Government	3,061	3,661	4,261	4,299	4,621	4,499	4,666
State and local government	1,222	1,659	1,700	2,054	2,481	2,911	2,978
Nonprofit organization	1,989	2,687	2,179	2,080	2,349	3,069	3,205
Other	963	1,236	1,412	1,394	1,471	1,623	1,580
Total engineers	45,050	50,342	57,039	61,545	65,853	67,768	74,783
Business and industry	22,868	26,517	31,788	34,500	37,858	37,147	41,959
Educational institution	15,917	17,074	18,042	20,320	21,697	23,710	25,122
Federal Government	3,519	3,571	3,803	3,843	3,807	3,606	4,546
State and local government	384	241	357	383	362	526	539
Nonprofit organization	1,551	2,016	2,338	1,921	1,714	2,174	2,189
Other	811	923	711	578	415	605	428
Aeronautical/astronautical	1,987	2,364	2,519	3,684	3,827	5,005	6,367
Business and industry	799	907	1,127	1,928	2,095	3,177	4,116
Educational institution	561	783	675	865	732	907	1,258
Federal Government	381	407	425	511	627	550	715
State and local government	0	0	0	1	0	0	0
Nonprofit organization	63	134	176	305	271	327	248
Other	183	133	116	74	102	44	30
Chemical	5,603	6,166	7,146	6,992	7,122	6,923	7,959
Business and industry	4,099	4,540	5,342	4,788	5,097	4,690	5,411
Educational institution	1,180	1,129	1,380	1,722	1,778	1,941	2,152
Federal Government	210	260	258	174	183	164	246
State and local government	8	0	23	0	0	0	14
Nonprofit organization	96	191	143	202	64	75	127
Other	10	46	0	106	0	53	9
Civil	4,066	5,157	6,089	5,317	6,396	6,479	6,951
Business and industry	1,199	1,822	2,555	1,895	2,426	1,931	2,426
Educational institution	2,211	2,722	2,887	3,138	3,409	3,802	3,667
Federal Government	279	249	145	79	295	387	432
State and local government	244	131	192	146	162	262	302
Nonprofit organization	13	0	69	16	14	49	73
Other	120	233	241	43	90	48	51
Electrical/electronic	8,284	8,597	10,630	12,696	14,248	12,601	15,088
Business and industry	3,915	4,687	6,187	7,615	8,566	7,600	8,780
Educational institution	3,290	2,930	3,592	3,960	4,672	3,979	4,829
Federal Government	620	719	524	776	756	637	950
State and local government	13	17	60	62	46	35	50
Nonprofit organization	320	184	264	218	186	254	377
Other	126	60	3	65	22	96	102

(continued)

Appendix table 3-15.

Employed doctoral scientists and engineers, by field and type of employer: 1977-89

(page 3 of 3)

Field and type of employer	1977	1979	1981	1983	1985	1987	1989
Mechanical	4,648	5,245	5,370	5,657	6,594	6,711	7,390
Business and industry	2,108	2,419	2,645	2,596	3,094	2,641	3,129
Educational institution	2,038	2,235	2,138	2,578	2,973	3,544	3,597
Federal Government	319	338	322	353	308	311	364
State and local government	0	1	2	0	0	8	7
Nonprofit organization	183	228	263	107	194	179	230
Other	0	24	0	23	25	28	63
Other engineers	20,462	22,813	25,285	27,199	27,666	30,049	31,028
Business and industry	10,748	12,142	13,932	15,678	16,580	17,108	18,097
Educational institution	6,637	7,275	7,370	8,057	8,133	9,537	9,619
Federal Government	1,710	1,598	2,129	1,950	1,638	1,557	1,839
State and local government	119	92	80	174	154	221	166
Nonprofit organization	876	1,279	1,423	1,073	985	1,290	1,134
Other	372	427	351	267	176	336	173

NOTE: Details may not sum to totals because of rounding.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317 (Washington, DC: NSF, 1991).

See figure 3-14 and figure O-11 in Overview.

Appendix table 3-16.
U.S. immigrant scientists and engineers, by country of origin: 1988

Country of origin	Total	Engineers	Natural scientists	Math scientists and computer specialists	Social scientists
All countries	10,918	8,081	1,198	1,164	475
Western Europe	1,674	1,173	257	165	79
France	93	67	10	13	3
Italy	50	30	14	2	4
Sweden	66	52	5	6	3
United Kingdom	776	553	107	92	24
West Germany	157	86	43	10	18
All others	532	385	78	42	27
Eastern Europe	723	465	112	34	112
Poland	313	173	60	10	70
USSR	153	116	17	8	12
Yugoslavia	53	36	8	1	8
All others	204	140	27	15	22
North and Central America	1,142	790	131	132	89
Canada	325	202	50	54	19
Mexico	201	148	28	17	8
All others	616	440	53	61	62
Near and Middle East	1,262	1,045	93	95	29
Iran	648	552	41	43	12
Israel	134	86	22	22	4
All others	480	407	30	30	13
Asia	4,986	3,831	463	615	77
Hong Kong	432	330	28	70	4
India	1,246	958	161	104	23
Japan	102	70	11	17	4
People's Republic of China	740	566	53	110	11
The Philippines	798	676	51	60	11
South Korea	183	152	14	16	1
Taiwan	907	646	83	171	7
All others	578	433	62	67	16
All other areas	1,131	777	142	123	89

NOTES: Data refer to scientists and engineers from all sectors. Country identification is based on the country of birth. "Immigrant" refers to those scientists and engineers allowed to stay permanently in the United States and obtain citizenship; it includes both those who came directly from a foreign country and those who changed to immigrant status while in the United States. It does *not* include those admitted on a temporary basis unless they changed their status to become immigrants.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

Science & Engineering Indicators – 1991

Appendix table 3-17.

Nonacademic scientists and engineers per 10,000 labor force, by gender for selected countries: most current years

	France (1987)	Italy (1981)	Japan (1985)	United Kingdom[1] (1981)	United States[2] (1986)	West Germany (1985)
Total numbers						
TOTAL SCIENTISTS & ENGINEERS	473,897	124,290	1,514,200	585,190	3,919,900	621,500
Male	405,389	110,137	1,444,400	533,380	3,393,700	585,400
Female	68,508	14,153	69,800	51,810	526,200	36,100
Scientists	202,541	63,402	389,900	219,740	1,676,400	114,100
Male	141,413	50,093	338,400	173,880	1,242,800	95,700
Female	55,128	13,309	51,500	45,860	433,600	18,400
Engineers	271,356	60,888	1,124,300	365,450	2,243,500	507,400
Male	257,976	60,044	1,106,000	359,500	2,150,900	489,700
Female	13,380	844	18,300	5,950	92,600	17,700
Per 10,000 labor force						
TOTAL SCIENTISTS & ENGINEERS	197	61	251	219	328	223
Male	168	54	240	199	284	210
Female	28	7	12	19	44	13
Scientists	84	31	65	82	140	41
Male	59	25	56	65	104	34
Female	23	7	9	17	36	7
Engineers	113	30	187	137	188	182
Male	107	30	184	134	180	176
Female	6	*	3	2	8	6
Labor force	24,073,000	20,246,000	60,270,700	26,740,000	119,540,000	27,844,000

* = less than 1 per 10,000

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Details may not sum to totals because of rounding. The numbers of scientists and engineers for France, Italy, Japan, the United Kingdom, and West Germany are estimates prepared by the U.S. Bureau of the Census based on published and unpublished census and survey data for the years shown. Labor force data are from the Organisation for Economic Cooperation and Development; thus, the number of scientists and engineers per 10,000 labor force differs from data published in Census Bureau reports.

[1] Data exclude Northern Ireland.

[2] Data by gender are estimates.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

See figure O-7 in Overview.

Science & Engineering Indicators – 1991

Appendix table 3-18.
Nonacademic scientists and engineers, by sector of employment in selected countries: most current years

Sector	France (1987)	Japan (1985)	United Kingdom[1] (1981)	United States (1988)	West Germany (1985)
			Scientists		
			Percent		
Total	100.0	100.0	100.0	100.0	100.0
Agriculture	*	*	0.5	1.0	0.2
Mining[2]	1.1	*	1.3	2.6	NA
Manufacturing	13.5	21.3	31.8	20.1	43.0
Construction	1.2	1.2	0.7	0.2	0.9
Wholesale and retail trade	5.1	9.2	4.8	3.7	2.2
Transportation, communications, and public utilities	1.5	2.1	5.5	2.7	2.9
Services	47.9	64.7	45.3	45.6	39.7
Government	29.4	1.0	10.1	24.0	7.4
All other	0.2	NA	0.1	NA	3.7
			Engineers		
Total	100.0	100.0	100.0	100.0	100.0
Agriculture	0.3	0.5	0.1	0.1	0.1
Mining[2]	3.9	0.4	2.0	1.9	NA
Manufacturing	34.2	32.6	52.4	51.8	43.9
Construction	6.6	23.0	9.7	1.7	10.5
Wholesale and retail trade	3.0	1.9	2.4	2.0	1.9
Transportation, communications, and public utilities	2.3	5.9	10.7	5.7	10.1
Services	26.9	31.0	17.0	23.3	21.0
Government	22.4	4.7	5.7	13.4	12.0
All other	0.2	NA	*	NA	0.5

* = less than 0.05 percent; NA = not available

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Details may not sum to 100 percent because of rounding. Figures for France, Japan, the United Kingdom, and West Germany are estimates prepared by the U.S. Bureau of the Census based on published and unpublished census and survey data for the years shown.

[1] Data exclude Northern Ireland.

[2] Mining data for West Germany are included under transportation, communications, and public utilities.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

See figure 3-18. *Science & Engineering Indicators – 1991*

Appendix table 3-19.

Total labor force and scientists and engineers engaged in R&D per 10,000 labor force, for selected countries: 1965-87

(page 1 of 2)

	France	Italy	Japan	Sweden	United Kingdom	United States	West Germany
Labor force (in thousands)							
1965	20,365	21,073	47,870	3,742	25,498	76,401	27,034
1966	20,534	20,836	48,910	3,792	25,632	77,892	26,962
1967	20,678	20,967	49,830	3,775	25,490	79,565	26,409
1968	20,861	21,039	50,610	3,822	25,378	80,990	26,291
1969	21,095	20,857	50,980	3,855	25,375	82,972	26,535
1970	21,415	20,886	51,530	3,913	25,308	84,889	26,817
1971	21,578	20,881	51,860	3,961	25,207	86,355	27,002
1972	21,738	20,713	52,000	3,970	25,264	88,847	26,990
1973	22,022	20,879	53,260	3,977	25,612	91,203	27,195
1974	22,260	21,046	53,100	4,043	25,659	93,670	27,147
1975	22,353	21,233	53,230	4,129	25,893	95,453	26,884
1976	22,605	21,553	53,780	4,155	26,111	97,826	26,651
1977	22,910	21,870	54,520	4,174	26,224	100,665	26,577
1978	23,062	21,950	55,320	4,290	26,357	103,882	26,692
1979	23,243	22,276	55,960	4,268	26,628	106,559	26,923
1980	23,369	22,553	56,500	4,318	26,840	108,544	27,217
1981	23,530	22,693	57,070	4,332	26,740	110,315	27,416
1982	23,743	22,798	57,740	4,357	26,677	111,872	27,542
1983	23,714	23,061	58,890	4,375	26,610	113,226	27,589
1984	23,867	23,323	59,270	4,332	27,265	115,241	27,629
1985	23,917	23,495	59,634	4,367	27,797	117,167	27,844
1986	23,993	23,851	60,200	4,386	27,984	119,540	28,024
1987	24,073	24,030	60,840	4,421	28,211	121,602	28,216
Scientists and engineers engaged in R&D per 10,000 labor force							
1965	21.0	NA	24.6	NA	19.6	64.7	22.6
1966	29.2	NA	26.4	NA	NA	66.9	22.3
1967	25.3	NA	27.8	NA	NA	67.2	24.4
1968	26.2	NA	31.1	NA	20.8	67.9	25.9
1969	27.1	12.2	30.8	NA	NA	66.6	28.2
1970	27.3	13.2	33.4	NA	NA	64.1	30.8
1971	27.9	14.8	37.5	22.9	NA	60.6	33.4
1972	28.2	15.7	38.1	NA	30.4	58.0	35.6
1973	28.5	16.0	42.5	23.2	NA	56.4	37.1
1974	28.8	16.3	44.9	NA	NA	55.6	37.8
1975	29.2	17.9	47.9	32.0	31.1	55.3	38.6
1976	29.6	17.6	48.4	NA	NA	54.7	39.2
1977	29.7	18.2	49.9	33.8	NA	55.7	41.8
1978	30.7	18.6	49.4	NA	33.3	56.5	42.7 *
1979	31.4	20.8	50.4	34.6	NA	57.7	43.4
1980	32.1	20.8	53.6	NA	NA	60.0	44.3 *
1981	36.3	22.9	55.6	35.2	35.8	61.9	45.5
1982	37.9	24.9	57.1	NA	NA	63.6	46.4 *
1983	39.1	27.3	58.1	39.0	35.4	66.4	47.4
1984	41.1	26.6	62.4	NA	35.5 *	69.2	49.6 *

(continued)

Appendix table 3-19.

Total labor force and scientists and engineers engaged in R&D per 10,000 labor force, for selected countries: 1965-87

(page 2 of 2)

	France	Italy	Japan	Sweden	United Kingdom	United States	West Germany
1985	42.8	27.1	63.9	44.9	35.5	72.5	51.6
1986	43.8 *	28.4	67.4	NA	35.5	75.0	52.3 *
1987	44.9 *	29.4	68.8	50.2	35.9	75.9	53.7 *

* = National Science Foundation estimates; NA = not available

NOTES: Table includes all scientists and engineers engaged in R&D on a full-time basis with the following exceptions. Japanese data include persons primarily employed in R&D in the natural sciences and engineering, and the United Kingdom data include only government and industry sectors. The figures for West Germany increased in 1979 because of increased coverage of small and medium enterprises not surveyed in 1977; data starting with 1979 were revised in 1988 using improved methodologies. The figures for France increased in 1981 in part because of a re-evaluation of university research methods.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

See figure 3-19. *Science & Engineering Indicators – 1991*

Appendix table 3-20.

Scientists and engineers engaged in R&D, by country: 1965-88

	France	Italy	Japan	Sweden	United Kingdom	United States	West Germany
				Thousands			
1965	42.8	NA	117.6	NA	49.9	494.6	61.0
1966	60.0	NA	128.9	NA	NA	521.1	60.0
1967	52.4	NA	138.7	NA	NA	534.4	64.5
1968	54.7	NA	157.6	NA	52.8	549.9	68.0
1969	57.2	25.4	157.1	NA	NA	552.7	74.9
1970	58.5	27.6	172.0	NA	NA	543.8	82.5
1971	60.1	30.9	194.3	9.1	NA	523.5	90.2
1972	61.2	32.6	198.1	NA	76.7	515.0	96.0
1973	62.7	33.3	226.6	9.2	NA	514.6	101.0
1974	64.1	34.3	238.2	NA	NA	520.6	102.5
1975	65.3	37.9	255.2	13.2	80.5	527.4	103.7
1976	67.0	37.9	260.2	NA	NA	535.2	104.5
1977	68.0	39.7	272.0	14.1	NA	560.6	111.0
1978	70.9	40.8	273.1	NA	87.7	586.6	113.9
1979	72.9	46.4	281.9	14.8	NA	614.5	116.9
1980	74.9	47.0	302.6	NA	NA	651.2	120.7
1981	85.5	52.1	317.5	15.2	95.7	683.3	124.7
1982	90.1	56.7	329.7	NA	NA	711.9	127.7
1983	92.7	63.0	342.2	17.0	94.1	751.7	130.8
1984	98.2	62.0	370.0	NA	96.3	797.8	137.1
1985	102.3	63.8	381.3	19.6	98.0	849.2	147.6
1986	105.0	67.8	405.6	NA	101.7	896.5	156.0
1987	109.4	70.6	418.3	22.2	101.4	923.3	165.6
1988	NA	NA	441.9	NA	NA	949.2	NA

NA = not available

NOTES: Table includes all scientists and engineers engaged in R&D on a full-time basis with the following exceptions. Japanese data include persons primarily employed in R&D in the natural sciences and engineering, and the United Kingdom data include only government and industry sectors. The figures for West Germany increased in 1979 because of increased coverage of small and medium enterprises not surveyed in 1977; data starting with 1979 were revised in 1988 using improved methodologies. The figures for France increased in 1981 in part because of a re-evaluation of university research efforts.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

See figure 3-19. *Science & Engineering Indicators – 1991*

Appendix table 3-21.
Scientists and engineers in manufacturing, by occupation group for selected countries: most current years

Occupation	France (1987)	Japan (1985)	United Kingdom[1] (1981)	United States (1988)	West Germany[2] (1985)
	Percent				
Total scientists and engineers	100.0	100.0	100.0	100.0	100.0
Scientists	24.4	25.7	27.0	20.5	18.4
Natural	8.0	4.4	12.3	10.0	10.9
Computer	14.6	21.2	14.1	10.4	NA
Social	1.9	0.1	0.6	0.1	7.4
Engineers	75.4	74.3	73.0	79.5	81.6
Civil	5.4	32.1	1.3	0.8	25.9
Electrical/electronic	25.5	15.4	12.6	25.0	13.0
Industrial/mechanical	44.7	26.8	59.0	53.7	42.8

NA = not separately available

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Details may not sum to totals because of rounding. Figures for France, Japan, the United Kingdom, and West Germany are estimates prepared by the U.S. Bureau of the Census based on published and unpublished census and survey data for the years shown.

[1] Data exclude Northern Ireland.

[2] Systems analysts are included with natural scientists; computer engineers are included with electrical/electronic engineers.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

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Appendix table 3-22.
Nonacademic scientists and engineers, by age group in selected countries: most current years

Age group	France (1987)	Japan (1985)	United Kingdom[1] (1981)	United States[2] (1986)	West Germany (1985)
	Percent				
Total	100.0	100.0	100.0	100.0	100.0
Under 35	28.2	48.5	38.9	32.9	30.3
35-54	61.7	44.9	32.1	49.0	56.0
Over 55	10.1	6.7	29.0	18.1	13.6

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Details may not sum to totals because of rounding. Figures for France, Japan, the United Kingdom, and West Germany are estimates prepared by the U.S. Bureau of the Census based on published and unpublished census and survey data for the years shown.

[1] Data exclude Northern Ireland.

[2] Data are for academic and nonacademic scientists and engineers and exclude those respondents for whom no age was reported.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

See figure 3-20. *Science & Engineering Indicators – 1991*

Appendix table 3-23.
First university degrees, by field of study for selected countries: most current years

Academic field	France[1] (1987)	Italy (1987)	Japan (1988)	Sweden (1987)	United Kingdom (1988)	United States (1988)	West Germany (1988)
			Number of degrees				
All fields	55,705	75,810	382,828	30,759	70,306	1,006,033	74,458
Natural science and engineering	26,606	23,423	102,911	3,796	25,990	196,934	26,081
Natural sciences	12,030	10,112	13,388	1,033	15,858	108,784	13,393
Engineering	14,576	10,295	76,362	2,236	8,839	70,406	10,444
Agriculture	NA	3,016	13,161	527	1,293	14,331	2,244
All others	29,099	52,387	279,917	26,963	44,316	809,099	48,377
			Percentage distribution among fields				
All fields	100.0	100.00	100.0	100.00	100.0	100.0	100.0
Natural science and engineering	47.8	30.9	26.9	12.3	37.0	19.6	35.0
Natural sciences	21.6	13.3	3.5	3.4	22.6	10.8	18.0
Engineering	26.2	13.6	19.9	7.3	12.6	7.0	14.0
Agriculture	NA	4.0	3.4	1.7	1.8	1.4	3.0
All others	52.2	69.1	73.1	87.7	63.0	80.4	65.0

NA = not separately available

NOTE: The natural sciences include physical and earth sciences, biological sciences, mathematics, and computer sciences. For France only, agriculture is included under the natural sciences.

[1] Data are based on maitrise degrees and engineering degrees. French engineering degrees are equivalent to U.S. masters degrees.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

See figure O-14 in Overview.

Appendix table 3-24.
Doctorates granted, by field of study for selected countries: most current years

Academic field	France[1] (1987)	Italy (1987)	Japan[2] (1988)	Sweden (1987)	United Kingdom[3] (1988)	United States (1988)	West Germany (1988)
Number of degrees							
All fields	7,965	2,145	9,156	956	7,588	33,456	17,321
Natural science and engineering	4,721	939	3,099	384	2,868	14,620	6,106
Natural sciences	4,439	518	837	191	1,312	9,415	4,275
Engineering	282	332	1,547	143	1,312	4,190	1,381
Agriculture	NA	89	715	50	244	1,015	450
All others	3,244	1,206	6,057	572	4,720	18,836	11,215
Percentage distribution among fields							
All fields	100.0	100.0	100.0	100	100.0	100.0	100.0
Natural science and engineering	59.3	43.8	33.8	40.2	37.8	43.7	35.3
Natural sciences	55.7	24.1	9.1	20.0	17.3	28.1	24.7
Engineering	3.5	15.5	16.9	15.0	17.3	12.5	8.0
Agriculture	NA	4.1	7.8	5.2	3.2	3.0	2.6
All others	40.7	56.2	66.2	59.8	62.2	56.3	64.7

NA = not separately available

NOTE: The natural sciences include physical and earth sciences, biological sciences, mathematics, and computer sciences. For France only, agriculture is included under the natural sciences.

[1] Data include the 3'eme Cycle and Docteur Ingenieur degrees, which are somewhat less than a Ph.D., and the Docteur d'etat, which is more than a Ph.D. France plans to grant a Ph.D.-level doctorate in the future.

[2] Ninety-four percent of "all other" Japanese doctorates are in health-related fields. Computer science is not a separate degree and is normally included in engineering.

[3] Data include Ph.D.-level and higher doctorates.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update: 1991*, NSF 91-309 (Washington, DC: NSF, 1991).

Appendix table 4-1.
GNP and GNP implicit price deflators: 1960-92

	GNP implicit price deflators		GNP	
	Calendar year	Fiscal year	Calendar year	Fiscal year
			— Billions of dollars —	
1960	0.3095	0.3111	515.3	507.8
1961	0.3124	0.3144	533.8	519.0
1962	0.3194	0.3200	574.7	556.7
1963	0.3240	0.3258	606.9	588.6
1964	0.3293	0.3305	649.8	629.4
1965	0.3378	0.3375	705.1	673.6
1966	0.3496	0.3474	772.0	740.5
1967	0.3594	0.3593	816.4	793.6
1968	0.3773	0.3719	892.7	852.4
1969	0.3978	0.3920	964.0	929.5
1970	0.4203	0.4148	1,015.5	990.5
1971	0.4438	0.4366	1,102.7	1,057.1
1972	0.4649	0.4606	1,212.8	1,151.2
1973	0.4954	0.4835	1,359.3	1,285.5
1974	0.5396	0.5216	1,472.8	1,417.0
1975	0.5931	0.5752	1,598.4	1,523.5
1976	0.6307	0.6208	1,782.8	1,699.6
1977	0.6728	0.6703	1,990.5	1,935.8
1978	0.7222	0.7172	2,249.7	2,173.4
1979	0.7857	0.7790	2,508.2	2,452.2
1980	0.8572	0.8474	2,732.0	2,667.7
1981	0.9396	0.9321	3,052.6	2,986.2
1982	1.0000	1.0000	3,166.0	3,141.5
1983	1.0386	1.0423	3,405.7	3,322.4
1984	1.0773	1.0819	3,772.2	3,695.7
1985	1.1095	1.1153	4,014.9	3,950.9
1986	1.1382	1.1451	4,231.6	4,184.3
1987	1.1743	1.1803	4,515.6	4,428.1
1988	1.2133	1.2162	4,873.7	4,783.2
1989	1.2631	1.2674	5,200.8	5,130.9
1990	1.3161	1.3182	5,465.1	5,405.6
1991	1.3741	1.3766	5,689.4	5,615.8
1992	1.4283	1.4329	6,094.9	5,985.5

NOTES: Calendar year deflators were taken directly from sources cited below. Fiscal year deflators were calculated from quarterly data in the same sources. Data are as of February 4, 1991.

SOURCES: Science Resources Studies Division, National Science Foundation, unpublished tabulations; Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: Department of Commerce, monthly series); and Office of Management and Budget, unpublished tabulations.

Science & Engineering Indicators – 1991

Appendix table 4-2.

U.S. R&D expenditures, by performing sector and source of funds: 1960-91

(page 1 of 2)

[Performing sector]		Federal Gov't	Industry			Universities and colleges (U&C)						U&C FFRDCs	Nonprofit institutions			
[Source of funds]	Total U.S.	Federal Gov't[1]	Total	Federal Gov't[1]	Industry	Total	Federal Gov't[1]	Industry	Non-Fed. gov't	U&C own	Non-profits	Federal Gov't[2]	Total	Federal Gov't[2]	Industry	Non-profits
	Millions of current dollars															
1960	13,520	1,723	10,509	6,081	4,428	646	405	40	85	64	52	360	282	166	48	68
1961	14,320	1,878	10,908	6,240	4,668	763	500	40	95	70	58	410	361	226	49	86
1962	15,392	2,096	11,464	6,435	5,029	904	613	40	106	79	66	470	458	295	54	109
1963	17,059	2,279	12,630	7,270	5,360	1,081	760	41	118	89	73	530	539	365	55	119
1964	18,854	2,838	13,512	7,720	5,792	1,275	917	40	132	103	83	629	600	433	55	112
1965	20,044	3,093	14,185	7,740	6,445	1,474	1,073	41	143	124	93	629	663	477	62	124
1966	21,846	3,220	15,548	8,332	7,216	1,715	1,261	42	156	148	108	630	733	525	70	138
1967	23,146	3,396	16,385	8,365	8,020	1,921	1,409	48	164	181	119	673	771	552	74	145
1968	24,605	3,494	17,429	8,560	8,869	2,149	1,572	55	172	218	132	719	814	582	81	151
1969	25,629	3,501	18,308	8,451	9,857	2,225	1,600	60	197	223	145	725	870	616	93	161
1970	26,134	4,079	18,067	7,779	10,288	2,335	1,647	61	219	243	165	737	916	649	95	172
1971	26,676	4,228	18,320	7,666	10,654	2,500	1,724	70	255	274	177	716	912	630	98	184
1972	28,476	4,589	19,552	8,017	11,535	2,630	1,795	74	269	305	187	753	952	653	101	198
1973	30,718	4,762	21,249	8,145	13,104	2,884	1,985	84	295	318	202	817	1,006	690	105	211
1974	32,863	4,911	22,887	8,220	14,667	3,022	2,032	95	308	368	219	865	1,178	822	115	241
1975	35,213	5,354	24,187	8,605	15,582	3,409	2,288	113	332	417	259	987	1,276	875	125	276
1976	39,018	5,769	26,997	9,561	17,436	3,729	2,512	123	364	446	285	1,147	1,376	925	135	316
1977	42,783	6,012	29,825	10,485	19,340	4,067	2,726	139	374	514	314	1,384	1,495	987	150	358
1978	48,128	6,810	33,304	11,189	22,115	4,625	3,059	170	414	623	359	1,717	1,672	1,100	165	407
1979	54,953	7,418	38,226	12,518	25,708	5,380	3,604	194	476	738	368	1,935	1,994	1,350	180	464
1980	62,610	7,632	44,505	14,029	30,476	6,077	4,104	236	496	837	403	2,246	2,150	1,450	200	500
1981	71,868	8,426	51,810	16,382	35,428	6,846	4,565	291	546	1,008	436	2,486	2,300	1,550	225	525
1982	80,018	9,141	58,650	18,545	40,105	7,323	4,763	337	616	1,115	492	2,479	2,425	1,650	250	525
1983	89,139	10,582	65,268	20,680	44,588	7,877	4,983	388	626	1,303	577	2,737	2,675	1,850	275	550
1984	101,139	11,572	74,800	23,396	51,404	8,617	5,423	475	690	1,413	615	3,150	3,000	2,100	325	575
1985	113,818	12,945	84,239	27,196	57,043	9,686	6,056	559	754	1,622	695	3,523	3,425	2,400	375	650
1986	119,529	13,535	87,823	27,891	59,932	10,926	6,702	699	916	1,873	735	3,895	3,350	2,250	425	675
1987	125,352	13,413	92,155	30,752	61,403	12,153	7,333	789	1,024	2,176	831	4,206	3,425	2,200	450	775
1988	133,741	14,281	97,889	32,306	65,583	13,465	8,181	870	1,107	2,367	941	4,531	3,575	2,200	500	875
1989	140,486	15,121	101,599	31,366	70,233	14,987	8,972	984	1,239	2,710	1,083	4,729	4,050	2,500	550	1,000
1990 (prel.)	145,450	16,100	104,200	31,200	73,000	16,000	9,250	1,100	1,350	3,100	1,200	4,800	4,350	2,650	600	1,100
1991 (est.)	151,600	16,400	108,450	32,300	76,150	17,200	9,650	1,250	1,500	3,450	1,350	4,850	4,700	2,800	650	1,250

(continued)

Appendix table 4-2.
U.S. R&D expenditures, by performing sector and source of funds: 1960-91
(page 2 of 2)

[Performing sector]		Federal Gov't	Industry			Universities and colleges (U&C)						U&C FFRDCs	Nonprofit institutions			
[Source of funds]	Total U.S.	Federal Gov't[1]	Total	Federal Gov't[1]	Industry	Total	Federal Gov't[1]	Industry	Non-Fed. gov't	U&C own	Non-profits	Federal Gov't[2]	Total	Federal Gov't[2]	Industry	Non-profits
	Millions of constant 1982 dollars[3]															
1960	43,639	5,539	33,955	19,648	14,307	2,077	1,302	129	273	206	167	1,157	911	536	155	220
1961	45,777	5,973	34,917	19,974	14,942	2,427	1,590	127	302	223	184	1,304	1,156	723	157	275
1962	48,171	6,551	35,892	20,147	15,745	2,825	1,916	125	331	247	206	1,469	1,434	924	169	341
1963	52,583	6,994	38,981	22,438	16,543	3,318	2,332	126	362	273	224	1,627	1,664	1,127	170	367
1964	57,203	8,587	41,032	23,444	17,589	3,858	2,775	121	399	312	251	1,903	1,822	1,315	167	340
1965	59,351	9,165	41,992	22,913	19,079	4,368	3,179	121	424	367	276	1,864	1,963	1,412	184	367
1966	62,589	9,269	44,474	23,833	20,641	4,937	3,630	121	449	426	311	1,813	2,097	1,502	200	395
1967	64,409	9,453	45,590	23,275	22,315	5,347	3,922	134	457	504	331	1,873	2,145	1,536	206	403
1968	65,458	9,395	46,194	22,688	23,506	5,778	4,227	148	462	586	355	1,933	2,157	1,543	215	400
1969	64,668	8,932	46,023	21,244	24,779	5,677	4,082	153	503	569	370	1,850	2,187	1,549	234	405
1970	62,403	9,833	42,986	18,508	24,478	5,629	3,970	147	528	586	398	1,777	2,179	1,544	226	409
1971	60,384	9,684	41,280	17,274	24,006	5,726	3,949	160	584	628	405	1,640	2,055	1,420	221	415
1972	61,412	9,963	42,056	17,245	24,812	5,710	3,897	161	584	662	406	1,635	2,048	1,405	217	426
1973	62,427	9,849	42,893	16,441	26,451	5,965	4,106	174	610	658	418	1,690	2,031	1,393	212	426
1974	61,466	9,416	42,415	15,234	27,181	5,794	3,896	182	591	706	420	1,658	2,183	1,523	213	447
1975	59,882	9,308	40,781	14,509	26,272	5,926	3,978	196	577	725	450	1,716	2,151	1,475	211	465
1976	62,134	9,293	42,805	15,159	27,645	6,007	4,046	198	586	718	459	1,848	2,182	1,467	214	501
1977	63,653	8,969	44,330	15,584	28,746	6,067	4,067	207	558	767	468	2,065	2,222	1,467	223	532
1978	66,768	9,495	46,115	15,493	30,622	6,449	4,265	237	577	869	501	2,394	2,315	1,523	228	564
1979	70,104	9,523	48,652	15,932	32,720	6,907	4,627	249	611	947	472	2,484	2,538	1,718	229	591
1980	73,255	9,006	51,919	16,366	35,553	7,171	4,843	278	585	988	476	2,650	2,508	1,692	233	583
1981	76,641	9,040	55,140	17,435	37,705	7,345	4,898	312	586	1,081	468	2,667	2,448	1,650	239	559
1982	80,018	9,141	58,650	18,545	40,105	7,323	4,763	337	616	1,115	492	2,479	2,425	1,650	250	525
1983	85,753	10,152	62,842	19,911	42,931	7,557	4,781	372	601	1,250	554	2,626	2,576	1,781	265	530
1984	93,790	10,696	69,433	21,717	47,716	7,965	5,012	439	638	1,306	568	2,912	2,785	1,949	302	534
1985	102,462	11,606	75,925	24,512	51,413	8,684	5,430	501	676	1,454	623	3,159	3,087	2,163	338	586
1986	104,866	11,820	77,160	24,504	52,655	9,542	5,853	610	800	1,636	642	3,401	2,943	1,977	373	593
1987	106,616	11,364	78,477	26,188	52,289	10,296	6,213	668	868	1,844	704	3,563	2,917	1,873	383	660
1988	110,166	11,742	80,680	26,627	54,053	11,072	6,727	715	910	1,946	774	3,726	2,947	1,813	412	721
1989	111,129	11,931	80,436	24,833	55,604	11,825	7,079	776	978	2,138	854	3,731	3,206	1,979	435	792
1990 (prel.)	110,470	12,213	79,173	23,706	55,467	12,137	7,017	834	1,024	2,352	910	3,641	3,305	2,014	456	836
1991 (est.)	110,277	11,914	78,924	23,506	55,418	12,495	7,010	908	1,090	2,506	981	3,523	3,420	2,038	473	910

NOTES: Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Expenditures for federally funded research and development centers (FFRDCs) administered by industry and nonprofit instutitions are included in the totals of the respective sector.

[1] Total funds used by Federal Government from Federal sources.

[2] FFRDCs administered by individual universities and colleges and by university consortia. In 1989, 99 percent of total funds used were from Federal sources.

[3] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1990, Final Report*, NSF 90-316 (Washington, DC: NSF, 1990); and unpublished tabulations.

See figure 4-1 and text table 4-1 and figure O-6 in Overview.

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Appendix table 4-3.
National expenditures for total R&D, by source of funds and performer: 1970-91

		Source of funds				Performer				
	Total	Federal Government	Industry	Universities & colleges[1]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[2]	Other nonprofits
					Millions of current dollars					
1970	26,134	14,891	10,444	462	337	4,079	18,067	2,335	737	916
1971	26,676	14,964	10,822	529	361	4,228	18,320	2,500	716	912
1972	28,476	15,807	11,710	574	385	4,589	19,552	2,630	753	952
1973	30,718	16,399	13,293	613	413	4,762	21,249	2,884	817	1,006
1974	32,863	16,850	14,877	676	460	4,911	22,887	3,022	865	1,178
1975	35,213	18,109	15,820	749	535	5,354	24,187	3,409	987	1,276
1976	39,018	19,914	17,694	809	601	5,769	26,997	3,729	1,147	1,376
1977	42,783	21,594	19,629	888	672	6,012	29,825	4,067	1,384	1,495
1978	48,128	23,875	22,450	1,037	766	6,810	33,304	4,625	1,717	1,672
1979	54,953	26,825	26,082	1,214	832	7,418	38,226	5,380	1,935	1,994
1980	62,610	29,461	30,912	1,334	903	7,632	44,505	6,077	2,246	2,150
1981	71,868	33,409	35,944	1,554	961	8,426	51,810	6,846	2,486	2,300
1982	80,018	36,578	40,692	1,731	1,017	9,141	58,650	7,323	2,479	2,425
1983	89,139	40,832	45,251	1,929	1,127	10,582	65,268	7,877	2,737	2,675
1984	101,139	45,641	52,204	2,104	1,190	11,572	74,800	8,617	3,150	3,000
1985	113,818	52,120	57,977	2,376	1,345	12,945	84,239	9,686	3,523	3,425
1986	119,529	54,273	61,056	2,790	1,410	13,535	87,823	10,926	3,895	3,350
1987	125,352	57,904	62,642	3,200	1,606	13,413	92,155	12,153	4,206	3,425
1988	133,741	61,499	66,953	3,473	1,816	14,281	97,889	13,465	4,531	3,575
1989	140,486	62,688	71,767	3,948	2,083	15,121	101,599	14,987	4,729	4,050
1990 (prel.) ..	145,450	64,000	74,700	4,450	2,300	16,100	104,200	16,000	4,800	4,350
1991 (est.) ...	151,600	66,000	78,[illegible]0	4,950	2,600	16,400	108,450	17,200	4,850	4,700
					Millions of constant 1982 dollars[3]					
1970	62,403	35,632	24,851	1,114	807	9,833	42,986	5,629	1,777	2,179
1971	60,384	33,965	24,387	1,212	820	9,684	41,280	5,726	1,640	2,055
1972	61,412	34,144	25,190	1,246	832	9,963	42,056	5,710	1,635	2,048
1973	62,427	33,478	26,837	1,268	844	9,849	42,893	5,965	1,690	2,031
1974	61,466	31,727	27,577	1,296	867	9,416	42,415	5,794	1,658	2,183
1975	59,882	30,985	26,679	1,302	916	9,308	40,781	5,926	1,716	2,151
1976	62,134	31,813	28,058	1,303	960	9,293	42,805	6,007	1,848	2,182
1977	63,653	32,152	29,176	1,325	1,001	8,969	44,330	6,067	2,065	2,222
1978	66,768	33,171	31,087	1,446	1,064	9,495	46,115	6,449	2,394	2,315
1979	70,104	34,284	33,198	1,558	1,063	9,523	48,652	6,907	2,484	2,538
1980	73,255	34,557	36,065	1,574	1,059	9,006	51,919	7,171	2,650	2,508
1981	76,641	35,690	38,257	1,667	1,027	9,040	55,140	7,345	2,667	2,448
1982	80,018	36,578	40,692	1,731	1,017	9,141	58,650	7,323	2,479	2,425
1983	85,753	39,251	43,568	1,851	1,083	10,152	62,842	7,557	2,626	2,576
1984	93,790	42,286	48,456	1,945	1,102	10,696	69,433	7,965	2,912	2,785
1985	102,462	46,870	52,252	2,130	1,209	11,606	75,925	8,684	3,159	3,087
1986	104,866	47,555	53,639	2,436	1,235	11,820	77,160	9,542	3,401	2,943
1987	106,616	49,201	53,341	2,711	1,364	11,364	78,477	10,296	3,563	2,917
1988	110,166	50,635	55,181	2,856	1,495	11,742	80,680	11,072	3,726	2,947
1989	111,129	49,553	56,815	3,115	1,646	11,931	80,436	11,825	3,731	3,206
1990 (prel.) ..	110,470	48,591	56,757	3,376	1,746	12,213	79,173	12,137	3,641	3,305
1991 (est.) ...	110,277	47,991	56,799	3,596	1,890	11,914	78,924	12,495	3,523	3,420

NOTES: Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Expenditures for federally funded research and development centers (FFRDCs) administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] Includes state and local government funds to the university and college sector.

[2] FFRDCs administered by individual universities and colleges (U&C) and by university consortia.

[3] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1990, Final Report*, NSF 90-316 (Washington, DC: NSF, 1990); and unpublished tabulations.

See figure 4-2.

Appendix table 4-4.
National expenditures for basic research, by source of funds and performer: 1970-91

		Source of funds				Performer				
	Total	Federal Government	Industry[1]	Universities & colleges[2]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[3]	Other nonprofits
	Millions of current dollars									
1970	3,531	2,471	528	350	182	559	602	1,796	269	305
1971	3,652	2,509	547	400	196	566	590	1,914	260	322
1972	3,801	2,605	563	415	218	597	593	2,022	244	345
1973	3,945	2,708	605	408	224	608	631	2,053	296	357
1974	4,343	3,017	650	431	245	696	699	2,153	390	405
1975	4,738	3,269	705	478	286	734	730	2,410	439	425
1976	5,130	3,589	769	475	297	786	819	2,549	512	464
1977	5,735	4,021	850	527	337	914	911	2,800	600	510
1978	6,692	4,745	964	605	378	1,029	1,035	3,176	867	585
1979	7,570	5,350	1,092	716	412	1,089	1,158	3,628	1,015	680
1980	8,432	5,909	1,271	796	456	1,182	1,325	4,041	1,124	760
1981	9,598	6,617	1,589	911	481	1,302	1,614	4,596	1,261	825
1982	10,433	7,098	1,833	1,002	500	1,465	1,904	4,882	1,317	865
1983	11,634	7,769	2,121	1,173	571	1,690	2,223	5,304	1,472	945
1984	12,909	8,489	2,566	1,257	597	1,861	2,608	5,735	1,675	1,030
1985	14,198	9,174	2,885	1,454	685	1,923	2,862	6,559	1,749	1,105
1986	16,590	9,991	4,132	1,739	728	2,019	4,047	7,495	1,859	1,170
1987	17,999	10,867	4,289	2,011	832	2,046	4,323	8,398	2,012	1,220
1988	18,673	11,542	4,110	2,101	920	2,050	4,244	8,827	2,222	1,330
1989	19,885	12,772	3,737	2,335	1,041	2,371	4,000	9,685	2,329	1,500
1990 (prel.)	21,920	13,650	4,530	2,600	1,140	2,600	4,750	10,350	2,500	1,720
1991 (est.)	23,500	14,450	4,875	2,900	1,275	2,800	5,050	11,100	2,600	1,950
	Millions of constant 1982 dollars[4]									
1970	8,483	5,946	1,257	844	436	1,347	1,432	4,329	648	726
1971	8,331	5,734	1,234	916	446	1,296	1,329	4,384	595	726
1972	8,233	5,649	1,212	901	472	1,296	1,276	4,390	530	742
1973	8,110	5,583	1,224	844	459	1,258	1,274	4,246	612	721
1974	8,256	5,758	1,208	826	463	1,334	1,295	4,128	748	751
1975	8,176	5,662	1,192	831	491	1,276	1,231	4,190	763	717
1976	8,231	5,770	1,221	765	475	1,266	1,299	4,106	825	736
1977	8,548	5,996	1,264	786	502	1,364	1,354	4,177	895	758
1978	9,315	6,610	1,336	844	525	1,435	1,433	4,428	1,209	810
1979	9,698	6,861	1,391	919	527	1,398	1,474	4,657	1,303	865
1980	9,922	6,963	1,485	939	535	1,395	1,546	4,769	1,326	887
1981	10,277	7,092	1,693	977	514	1,397	1,718	4,931	1,353	878
1982	10,433	7,098	1,833	1,002	500	1,465	1,904	4,882	1,317	865
1983	11,172	7,457	2,041	1,125	549	1,621	2,140	5,089	1,412	910
1984	11,946	7,851	2,381	1,162	553	1,720	2,421	5,301	1,548	956
1985	12,749	8,231	2,599	1,304	615	1,724	2,580	5,881	1,568	996
1986	14,515	8,732	3,628	1,519	637	1,763	3,556	6,545	1,623	1,028
1987	15,273	9,213	3,650	1,704	706	1,733	3,681	7,115	1,705	1,039
1988	15,365	9,494	3,386	1,728	757	1,686	3,498	7,258	1,827	1,096
1989	15,704	10,082	2,957	1,842	822	1,871	3,167	7,642	1,838	1,188
1990 (prel.)	16,636	10,357	3,441	1,972	865	1,972	3,609	7,851	1,896	1,307
1991 (est.)	17,081	10,500	3,547	2,107	927	2,034	3,675	8,064	1,889	1,419

NOTES: Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Expenditures for federally funded research and development centers (FFRDCs) administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] Imputation procedure for industry funding of industry basic research changed for 1986 and later years. These data may not be comparable to data for 1985 and earlier years.

[2] Includes state and local government funds to the university and college sector.

[3] FFRDCs administered by individual universities and colleges (U&C) and by university consortia.

[4] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1990, Final Report*, NSF 90-316 (Washington, DC: NSF, 1990); and unpublished tabulations.

See figures 4-2 and 4-3 and figure O-4 in Overview. *Science & Engineering Indicators – 1991*

Appendix table 4-5.
National expenditures for applied research, by source of funds and performer: 1970-91

		Source of funds				Performer				
	Total	Federal Government	Industry[1]	Universities & colleges[2]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[3]	Other nonprofits
	Millions of current dollars									
1970	5,738	3,097	2,427	99	115	1,345	3,427	427	216	323
1971	5,759	3,028	2,494	115	122	1,322	3,415	474	210	338
1972	6,011	3,131	2,615	140	125	1,387	3,514	524	221	365
1973	6,598	3,395	2,891	172	140	1,480	3,825	713	227	353
1974	7,189	3,495	3,332	203	159	1,574	4,288	736	178	413
1975	7,812	3,889	3,517	224	182	1,730	4,570	851	213	448
1976	8,983	4,471	4,003	282	227	2,093	5,112	1,016	264	498
1977	9,651	4,692	4,410	303	246	2,044	5,636	1,067	371	533
1978	10,725	5,110	4,981	354	280	2,191	6,300	1,213	431	590
1979	12,272	5,768	5,796	413	295	2,392	7,225	1,477	468	710
1980	13,860	6,408	6,693	445	314	2,484	8,450	1,698	503	725
1981	16,605	7,198	8,534	534	339	2,732	10,699	1,865	529	780
1982	18,510	7,973	9,566	608	363	2,729	12,323	2,037	606	815
1983	20,694	9,181	10,506	621	386	3,020	13,927	2,146	726	875
1984	22,851	9,927	11,809	700	415	2,903	15,765	2,459	804	920
1985	25,831	11,408	13,216	756	451	3,133	18,255	2,673	835	935
1986	27,566	10,808	15,436	856	466	3,141	19,760	2,911	774	980
1987	28,096	11,059	15,541	965	531	3,392	19,813	3,168	693	1,030
1988	29,875	11,470	16,651	1,129	625	3,288	20,757	3,993	697	1,140
1989	33,300	12,453	18,784	1,337	726	3,611	23,086	4,581	722	1,300
1990 (prel.)	33,895	12,675	18,870	1,530	820	3,800	23,050	4,845	750	1,450
1991 (est.)	35,390	13,100	19,655	1,700	935	4,100	23,900	5,220	700	1,470
	Millions of constant 1982 dollars[4]									
1970	13,714	7,426	5,775	239	275	3,242	8,154	1,029	521	768
1971	13,051	6,891	5,620	263	277	3,028	7,695	1,086	481	762
1972	12,972	6,773	5,625	304	270	3,011	7,559	1,138	480	785
1973	13,439	6,961	5,837	356	285	3,061	7,721	1,475	469	713
1974	13,482	6,617	6,177	389	299	3,018	7,947	1,411	341	765
1975	13,318	6,686	5,932	389	311	3,007	7,705	1,479	370	755
1976	14,328	7,163	6,348	454	363	3,371	8,105	1,637	425	790
1977	14,364	6,991	6,555	452	366	3,049	8,377	1,592	553	792
1978	14,888	7,107	6,898	494	389	3,055	8,723	1,691	601	817
1979	15,667	7,382	7,378	530	377	3,071	9,196	1,896	601	904
1980	16,232	7,530	7,809	525	368	2,931	9,858	2,004	594	846
1981	17,717	7,698	9,083	573	362	2,931	11,387	2,001	568	830
1982	18,510	7,973	9,566	608	363	2,729	12,323	2,037	606	815
1983	19,905	8,823	10,115	596	371	2,897	13,409	2,059	697	842
1984	21,187	9,194	10,961	647	384	2,683	14,634	2,273	743	854
1985	23,250	10,256	11,911	678	405	2,809	16,453	2,397	749	843
1986	24,183	9,466	13,561	748	408	2,743	17,361	2,542	676	861
1987	23,894	9,392	13,233	818	451	2,874	16,872	2,684	587	877
1988	24,607	9,441	13,723	928	515	2,704	17,108	3,283	573	940
1989	26,340	9,841	14,870	1,055	574	2,849	18,277	3,614	570	1,029
1990 (prel.)	25,742	9,622	14,337	1,161	623	2,883	17,514	3,675	569	1,102
1991 (est.)	25,742	9,524	14,303	1,235	680	2,978	17,393	3,792	509	1,070

NOTES: Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Since 1978 the applied research/development split for the academic sector has been estimated. Expenditures for federally funded research and development centers (FFRDCs) administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] Imputation procedure for industry funding of industry applied research changed for 1986 and later years. These data may not be comparable to data for 1985 and earlier years.

[2] Includes state and local government funds to the university and college sector.

[3] FFRDCs administered by individual universities and colleges (U&C) and by university consortia.

[4] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1990, Final Report*, NSF 90-316 (Washington, DC: NSF, 1990); and unpublished tabulations.

See figures 4-2 and 4-3 and figure O-4 in Overview.

Appendix table 4-6.
National expenditures for development, by source of funds and performer: 1970-91

		Source of funds				Performer				
	Total	Federal Government	Industry[1]	Universities & colleges[2]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[3]	Other nonprofits
Millions of current dollars										
1970	16,865	9,323	7,489	13	40	2,175	14,038	112	252	288
1971	17,265	9,427	7,781	14	43	2,340	14,315	112	246	252
1972	18,664	10,071	8,532	19	42	2,605	15,445	84	288	242
1973	20,175	10,296	9,797	33	49	2,674	16,793	118	294	296
1974	21,331	10,338	10,895	42	56	2,641	17,900	133	297	360
1975	22,663	10,951	11,598	47	67	2,890	18,887	148	335	403
1976	24,905	11,854	12,922	52	77	2,890	21,066	164	371	414
1977	27,397	12,881	14,369	58	89	3,054	23,278	200	413	452
1978	30,711	14,020	16,505	78	108	3,590	25,969	236	419	497
1979	35,111	15,707	19,194	85	125	3,937	29,843	275	452	604
1980	40,318	17,144	22,948	93	133	3,966	34,730	338	619	665
1981	45,665	19,594	25,821	109	141	4,392	39,497	385	696	695
1982	51,075	21,507	29,293	121	154	4,947	44,423	404	556	745
1983	56,811	23,882	32,624	135	170	5,872	49,118	427	539	855
1984	65,379	27,225	37,829	147	178	6,808	56,427	423	671	1,050
1985	73,789	31,538	41,876	166	209	7,889	63,122	454	939	1,385
1986	75,373	33,474	41,488	195	216	8,375	64,016	520	1,262	1,200
1987	79,257	35,978	42,812	224	243	7,975	68,019	587	1,501	1,175
1988	85,193	38,487	46,192	243	271	8,943	72,888	645	1,612	1,105
1989	87,301	37,463	49,246	276	316	9,139	74,513	721	1,678	1,250
1990 (prel.)	89,635	37,675	51,300	320	340	9,700	76,400	805	1,550	1,180
1991 (est.)	92,710	38,450	53,520	350	390	9,500	79,500	880	1,550	1,280
Millions of constant 1982 dollars[4]										
1970	40,206	22,260	17,818	31	95	5,243	33,400	270	607	685
1971	39,003	21,341	17,533	32	97	5,359	32,256	257	563	568
1972	40,206	21,722	18,352	41	90	5,656	33,222	182	625	521
1973	40,878	20,934	19,776	68	99	5,531	33,898	244	608	597
1974	39,728	19,351	20,191	81	105	5,064	33,173	255	569	667
1975	38,388	18,637	19,555	82	114	5,024	31,845	257	582	679
1976	39,574	18,880	20,489	84	122	4,655	33,401	264	598	656
1977	40,741	19,165	21,357	87	132	4,556	34,599	298	616	672
1978	42,565	19,453	22,854	109	150	5,006	35,958	329	584	688
1979	44,739	20,041	24,429	109	159	5,054	37,983	353	580	769
1980	47,101	20,065	26,771	110	156	4,680	40,516	399	730	776
1981	48,648	20,899	27,481	117	150	4,712	42,036	413	747	740
1982	51,075	21,507	29,293	121	154	4,947	44,423	404	556	745
1983	54,676	22,972	31,411	130	164	5,634	47,293	410	517	823
1984	60,657	25,241	35,115	136	165	6,293	52,378	391	620	975
1985	66,463	28,383	37,743	149	188	7,073	56,892	407	842	1,248
1986	66,167	29,357	36,450	170	190	7,314	56,243	454	1,102	1,054
1987	67,449	30,595	36,457	190	207	6,757	57,923	497	1,272	1,001
1988	70,194	31,700	38,071	200	223	7,353	60,074	530	1,325	911
1989	69,085	29,630	38,988	218	250	7,211	58,992	569	1,324	990
1990 (prel.)	68,092	28,612	38,979	243	258	7,358	58,050	611	1,176	897
1991 (est.)	67,454	27,967	38,949	254	284	6,901	57,856	639	1,126	932

NOTES: Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Since 1978, the applied research/development split for the academic sector has been estimated. Expenditures for federally funded research and development centers (FFRDCs) administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] Imputation procedure for industry funding of industry development changed for 1986 and later years. These data may not be comparable to data for 1985 and earlier years.

[2] Includes state and local government funds to the university and college sector.

[3] FFRDCs administered by individual universities and colleges (U&C) and by university consortia.

[4] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1990. Final Report*, NSF 90-316 (Washington, DC: NSF, 1990); and unpublished tabulations.

See figures 4-2 and 4-3 and figure O-4 in Overview.

Appendix table 4-7.
Industrial R&D, by character of work, industry classification, and source of funds: 1989

	Total			Basic			Applied			Development			Not distributed		
Industry	Total	Federal	Other	Total	Federal	Other	Total	Federal	Other	Total	Federal	Other	Total	Federal	Other
	Millions of current dollars														
Estimated total	101,599	31,366	70,233	4,000	1,095	2,905	23,086	4,825	18,261	74,513	25,446	49,067	0	0	0
Reported total	101,599	31,366	70,233	2,992	837	2,155	17,356	3,665	13,691	55,555	17,948	37,607	25,696	8,916	16,780
Food, kindred, and tobacco products	D	D	1,283	19	0	19	D	D	368	D	D	622	274	0	274
Textiles and apparel	D	D	S	D	D	D	S	0	S	D	D	S	54	0	54
Lumber, wood products, and furniture	170	0	170	D	0	D	39	0	39	68	0	68	46	0	46
Paper and allied products	683	0	683	29	0	29	121	0	121	323	0	323	210	0	210
Chemicals and allied products	11,537	87	11,450	534	8	526	3,350	S	3,333	4,118	57	4,061	3,535	5	3,530
Industrial chemicals	4,056	84	3,972	227	8	219	D	D	1,095	1,516	57	1,460	1,203	4	1,198
Drugs and medicines	D	D	5,206	S	0	S	D	D	1,378	D	D	1,629	1,926	1	1,925
Other chemicals	D	D	2,271	33	0	33	D	D	860	D	D	972	406	0	406
Petroleum refining and extraction	2,066	S	2,050	D	D	72	673	1	672	653	3	650	667	11	656
Rubber products	D	D	679	17	0	17	D	D	81	D	D	191	390	0	390
Stone, clay, and glass products	D	D	861	D	D	170	D	D	394	D	D	245	52	0	52
Primary metals	768	34	734	S	0	S	D	D	199	341	20	321	147	0	147
Fabricated metal products	788	135	653	23	0	23	D	D	109	376	75	301	267	47	220
Machinery	D	D	13,216	D	D	S	D	D	2,722	D	D	S	1,579	80	1,499
Office, computing, & acctg machines	D	D	10,533	D	D	S	D	D	2,220	D	D	S	1,079	0	1,079
Other machinery, except electrical	2,789	106	2,683	50	0	50	509	7	502	1,730	19	1,711	500	80	420
Electrical equipment	16,768	5,222	11,546	378	10	368	2,894	568	2,326	10,001	3,442	6,559	3,495	1,202	2,293
Radio and TV receiving equipment	85	0	85	S	0	S	D	0	D	D	0	D	51	0	51
Communication equipment	10,508	4,666	5,842	D	D	D	1,161	D	D	7,341	3,158	4,183	1,742	1,055	687
Electronic components	4,884	522	4,362	D	D	39	D	D	1,387	D	D	1,720	1,350	134	1,216
Other electrical equipment	1,292	35	1,257	D	0	D	215	0	215	D	D	D	355	14	341
Transportation equipment	36,863	21,763	15,100	478	336	142	3,129	1,668	1,461	22,475	12,665	9,810	10,781	7,094	3,687
Motor vehicles and other transportation equipment	11,209	2,129	9,080	65	0	65	685	92	593	6,775	1,185	5,590	3,684	852	2,832
Aircraft and missiles	25,654	19,634	6,020	413	336	77	2,444	1,576	868	15,700	11,480	4,220	7,097	6,242	855
Professional and scientific instruments	5,763	125	5,638	D	D	196	688	21	667	D	D	1,991	2,798	14	2,784
Other manufacturing industries	D	D	402	28	0	28	D	D	51	D	D	249	74	0	74
Nonmanufacturing industries	8,273	2,716	5,557	720	466	254	1,881	768	1,113	4,348	1,022	3,326	1,324	460	864

D = withheld to avoid disclosing operations of individual companies
S = withheld because of imputation of more than 50 percent

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

Appendix table 4-8.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980-91

(page 1 of 4)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991(est.)
Total research & development												
	Millions of current dollars											
Total, all agencies	29,830	33,104	36,433	38,712	42,225	48,360	51,412	55,255	56,935	61,406	64,896	64,261
Dept. of Agriculture	688	774	797	848	866	943	929	948	1,017	1,038	1,112	1,224
Dept. of Commerce	343	328	336	335	358	399	399	402	389	398	434	527
Dept. of Defense	13,981	16,509	20,623	22,993	25,373	29,792	32,938	35,232	35,415	37,577	38,694	35,188
Dept. of Education	139	105	128	112	116	125	121	133	141	159	161	204
Dept. of Energy	4,754	4,918	4,708	4,537	4,674	4,966	4,688	4,757	5,036	5,193	5,545	6,057
Dept. of Health & Human Services	3,780	3,927	3,941	4,353	4,831	5,451	5,658	6,609	7,158	7,903	8,474	9,336
National Institutes of Health	3,182	3,333	3,433	3,789	4,257	4,828	5,005	5,853	6,291	6,778	7,137	7,714
Dept. of Housing & Urban Develop	56	48	29	32	18	19	15	16	18	18	18	30
Dept. of the Interior	411	427	381	383	411	392	385	404	417	469	511	586
Dept. of Labor	138	62	25	20	16	13	10	22	36	35	27	29
Dept. of Transportation	361	416	310	348	448	429	386	324	304	303	366	414
Environmental Protection Agency	345	326	335	241	261	320	317	348	347	380	420	425
National Aeronautics & Space Admin	3,234	3,593	3,078	2,662	2,822	3,327	3,420	3,787	4,330	5,393	6,535	7,435
National Science Foundation	882	962	975	1,062	1,203	1,346	1,353	1,471	1,533	1,670	1,669	1,828
All other agencies	719	710	766	789	828	839	793	804	794	870	930	978
Basic research												
Total, all agencies	4,674	5,041	5,482	6,260	7,067	7,819	8,153	8,944	9,474	10,602	11,277	12,382
Dept. of Agriculture	276	314	331	362	393	445	433	445	481	485	518	563
Dept. of Commerce	16	16	17	19	21	23	27	26	31	29	31	31
Dept. of Defense	540	604	687	786	848	861	924	908	877	948	948	1,022
Dept. of Education	18	21	14	14	12	15	5	3	4	4	5	7
Dept. of Energy	523	586	642	768	830	943	960	1,068	1,185	1,411	1,501	1,741
Dept. of Health & Human Services	1,763	1,900	2,145	2,475	2,815	3,233	3,339	3,830	4,081	4,388	4,660	5,101
National Institutes of Health	1,642	1,767	2,021	2,313	2,625	3,018	3,119	3,577	3,795	4,053	4,251	4,634
Dept. of Housing & Urban Develop	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	72	81	77	103	126	138	133	135	126	189	207	231
Dept. of Labor	4	4	7	5	5	3	1	1	1	1	6	6
Dept. of Transportation	0	1	1	1	4	1	1	0	0	0	0	0
Environmental Protection Agency	14	11	33	22	30	39	39	31	27	51	74	97
National Aeronautics & Space Admin	559	531	536	617	755	751	917	1,014	1,113	1,417	1,637	1,730
National Science Foundation	815	897	916	999	1,132	1,262	1,275	1,371	1,433	1,563	1,570	1,719
All other agencies	76	76	78	89	98	105	102	113	115	116	120	135
Applied research												
Total, all agencies	6,923	7,172	7,541	7,993	7,911	8,315	8,349	8,999	9,176	10,163	10,427	11,563
Dept. of Agriculture	382	427	436	456	442	466	464	473	505	517	542	606
Dept. of Commerce	239	233	259	266	276	301	313	313	311	322	366	433
Dept. of Defense	1,721	1,997	2,266	2,437	2,201	2,307	2,303	2,440	2,362	2,708	2,590	2,662
Dept. of Education	70	33	56	62	69	77	91	104	107	118	120	150
Dept. of Energy	754	827	1,054	1,193	1,195	1,198	1,081	1,029	1,051	1,021	1,048	1,220
Dept. of Health & Human Services	1,570	1,592	1,461	1,545	1,652	1,796	1,851	2,195	2,416	2,700	2,901	3,218
National Institutes of Health	1,145	1,182	1,104	1,165	1,286	1,410	1,469	1,740	1,886	2,008	2,112	2,264
Dept. of Housing & Urban Develop	20	17	10	11	6	7	5	6	6	6	7	11
Dept. of the Interior	283	289	275	255	254	231	235	247	266	253	270	315
Dept. of Labor	33	55	11	13	11	9	9	19	26	22	17	18
Dept. of Transportation	82	87	66	72	74	70	68	68	91	120	119	146
Environmental Protection Agency	232	208	211	152	142	176	179	246	241	223	242	246
National Aeronautics & Space Admin	1,051	876	871	928	955	1,033	1,152	1,256	1,219	1,461	1,424	1,734
National Science Foundation	58	59	57	63	71	84	78	99	100	108	99	109
All other agencies	429	472	508	541	564	560	520	503	475	584	682	695

(continued)

Appendix table 4-8.
Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980-91
(page 2 of 4)

Agency	1980.	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991(est.)
Development												
	Millions of current dollars											
Total, all agencies	18,233	20,891	23,410	24,458	27,246	32,226	34,910	37,313	38,285	40,640	43,192	40,316
Dept. of Agriculture	30	33	31	30	31	32	32	29	31	36	52	55
Dept. of Commerce	88	79	60	50	62	75	60	64	47	47	37	62
Dept. of Defense	11,719	13,908	17,670	19,770	22,324	26,623	29,711	31,884	32,176	33,921	35,155	31,504
Dept. of Education	52	51	58	36	35	33	26	26	30	37	37	47
Dept. of Energy	3,476	3,505	3,012	2,576	2,649	2,825	2,648	2,659	2,801	2,761	2,996	3,096
Dept. of Health & Human Services	447	435	335	332	365	423	468	584	661	814	913	1,018
National Institutes of Health	394	385	309	311	347	400	418	536	610	717	773	817
Dept. of Housing & Urban Develop	36	31	19	21	12	12	10	11	12	12	12	19
Dept. of the Interior	57	57	30	25	31	22	17	22	24	27	34	40
Dept. of Labor	102	4	8	2	0	1	1	1	9	13	4	5
Dept. of Transportation	279	327	243	275	371	358	317	256	213	182	247	269
Environmental Protection Agency	100	107	92	66	89	106	100	71	80	107	104	83
National Aeronautics & Space Admin	1,624	2,186	1,671	1,117	1,113	1,544	1,351	1,518	1,999	2,515	3,474	3,971
National Science Foundation	8	6	2	0	0	0	0	0	0	0	0	0
All other agencies	214	162	180	159	166	173	170	188	202	168	128	148
R&D plant												
Total, all agencies	1,556	1,486	1,390	1,298	1,787	1,821	1,539	1,846	2,057	2,967	2,385	3,398
Dept. of Agriculture	57	21	21	34	39	41	79	112	135	124	96	151
Dept. of Commerce	5	1	1	1	9	4	9	5	11	16	15	19
Dept. of Defense	208	278	291	313	529	531	286	477	436	615	518	509
Dept. of Education	0	0	0	0	0	1	7	21	5	9	9	7
Dept. of Energy	1,024	978	914	758	852	868	742	772	915	1043	1,015	1,233
Dept. of Health & Human Services	31	24	25	48	31	42	38	37	20	131	87	245
National Institutes of Health	29	22	19	18	28	29	29	35	19	130	84	233
Dept. of Housing & Urban Develop	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	8	3	1	2	5	4	4	12	9	12	11	15
Dept. of Labor	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of Transportation	23	19	12	22	17	9	12	11	14	19	22	21
Environmental Protection Agency	0	0	0	0	0	0	0	0	0	0	0	13
National Aeronautics & Space Admin	159	116	114	101	244	234	275	309	428	853	526	949
National Science Foundation	19	15	2	3	45	74	53	61	57	119	64	206
All other agencies	23	31	10	17	14	13	33	28	32	26	24	30
R&D and R&D plant												
Total, all agencies	31,386	34,590	37,822	40,010	44,012	50,180	52,951	57,101	58,992	64,373	67,281	67,659
Dept. of Agriculture	745	795	819	881	905	984	1,008	1,060	1,152	1,162	1,208	1,376
Dept. of Commerce	347	329	337	336	368	403	409	407	400	414	449	546
Dept. of Defense	14,189	16,786	20,913	23,305	25,902	30,322	33,224	35,709	35,851	38,192	39,212	35,698
Dept. of Education	139	105	128	112	116	126	128	154	141	168	170	211
Dept. of Energy	5,778	5,896	5,622	5,294	5,526	5,834	5,431	5,529	5,951	6,236	6,560	7,289
Dept. of Health & Human Services	3,811	3,951	3,965	4,400	4,862	5,493	5,696	6,645	7,178	8,034	8,561	9,581
National Institutes of Health	3,211	3,356	3,453	3,807	4,285	4,857	5,035	5,889	6,310	6,908	7,221	7,947
Dept. of Housing & Urban Develop	56	48	29	32	18	19	15	16	18	18	18	30
Dept. of the Interior	419	431	382	385	416	396	390	416	426	481	522	600
Dept. of Labor	138	62	25	20	16	13	10	22	36	35	27	29
Dept. of Transportation	385	434	322	370	465	438	398	336	318	322	387	435
Environmental Protection Agency	345	326	335	241	261	320	317	348	347	380	420	439
National Aeronautics & Space Admin	3,393	3,709	3,192	2,763	3,066	3,562	3,695	4,097	4,758	6,246	7,060	8,384
National Science Foundation	901	976	977	1,065	1,248	1,419	1,407	1,532	1,590	1,789	1,733	2,034
All other agencies	741	741	775	805	842	851	825	832	826	896	954	1,008

(continued)

Appendix table 4-8.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980-91

(page 3 of 4)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991(est.)
Total research & development												
	Millions of constant 1982 dollars[1]											
Total, all agencies	35,202	35,517	36,433	37,140	39,028	43,359	44,898	46,813	46,815	48,450	47,143	46,682
Dept. of Agriculture	811	830	797	813	801	845	811	803	836	819	808	889
Dept. of Commerce	404	352	336	321	331	358	349	341	320	314	315	383
Dept. of Defense	16,499	17,712	20,623	22,059	23,452	26,711	28,764	29,849	29,120	29,649	28,109	25,562
Dept. of Education	165	113	128	107	107	112	106	112	116	125	117	148
Dept. of Energy	5,610	5,277	4,708	4,352	4,320	4,452	4,094	4,030	4,141	4,097	4,028	4,400
Dept. of Health & Human Services	4,461	4,213	3,941	4,176	4,465	4,887	4,941	5,599	5,886	6,236	6,156	6,782
National Institutes of Health	3,755	3,576	3,433	3,635	3,935	4,328	4,371	4,959	5,173	5,348	5,185	5,604
Dept. of Housing & Urban Develop	66	52	29	31	17	17	13	14	15	14	13	22
Dept. of the Interior	485	458	381	367	380	351	336	342	343	370	371	426
Dept. of Labor	163	67	25	19	15	12	9	18	30	28	20	21
Dept. of Transportation	426	446	310	334	414	385	337	275	250	239	266	301
Environmental Protection Agency	407	349	335	231	241	287	277	295	285	300	305	309
National Aeronautics & Space Admin	3,816	3,855	3,078	2,554	2,608	2,983	2,986	3,208	3,560	4,255	4,747	5,401
National Science Foundation	1,041	1,032	975	1,019	1,112	1,206	1,182	1,246	1,261	1,318	1,213	1,328
All other agencies	848	762	766	757	765	752	692	681	653	686	676	710
Basic research												
Total, all agencies	5,516	5,409	5,482	6,006	6,532	7,010	7,120	7,578	7,790	8,365	8,554	8,995
Dept. of Agriculture	325	337	331	347	363	399	378	377	396	383	393	409
Dept. of Commerce	19	17	17	18	19	21	23	22	25	23	24	23
Dept. of Defense	638	648	687	754	784	772	807	769	721	748	719	743
Dept. of Education	21	22	14	14	11	13	4	3	3	3	3	5
Dept. of Energy	617	629	642	737	768	845	838	905	974	1,113	1,138	1,264
Dept. of Health & Human Services	2,080	2,039	2,145	2,375	2,601	2,898	2,916	3,244	3,356	3,462	3,535	3,705
National Institutes of Health	1,938	1,896	2,021	2,219	2,426	2,706	2,723	3,031	3,120	3,198	3,225	3,366
Dept. of Housing & Urban Develop	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	84	87	77	99	116	124	116	114	104	149	157	168
Dept. of Labor	5	4	7	5	5	3	1	1	1	1	5	4
Dept. of Transportation	0	1	1	1	3	1	1	0	0	0	0	0
Environmental Protection Agency	16	11	33	21	27	35	34	26	22	40	56	70
National Aeronautics & Space Admin	660	570	536	592	697	673	801	859	915	1,118	1,242	1,256
National Science Foundation	962	962	916	959	1,047	1,131	1,114	1,162	1,178	1,233	1,191	1,249
All other agencies	89	81	78	85	91	94	89	95	95	92	91	98
Applied research												
Total, all agencies	8,170	7,694	7,541	7,669	7,312	7,455	7,291	7,624	7,545	8,019	7,910	8,400
Dept. of Agriculture	451	458	436	437	409	417	405	401	415	408	411	441
Dept. of Commerce	281	250	259	255	255	270	273	265	256	254	278	315
Dept. of Defense	2,031	2,142	2,266	2,338	2,034	2,068	2,011	2,067	1,942	2,137	1,965	1,934
Dept. of Education	83	36	56	59	63	69	80	88	88	93	91	109
Dept. of Energy	890	888	1,054	1,145	1,104	1,074	944	872	864	806	795	886
Dept. of Health & Human Services	1,853	1,708	1,461	1,483	1,526	1,610	1,616	1,859	1,987	2,130	2,201	2,337
National Institutes of Health	1,351	1,268	1,104	1,118	1,188	1,264	1,283	1,474	1,551	1,584	1,602	1,645
Dept. of Housing & Urban Develop	23	18	10	11	6	6	5	5	5	5	5	8
Dept. of the Interior	334	310	275	244	235	207	205	210	219	200	205	229
Dept. of Labor	38	58	11	12	10	8	8	16	21	17	13	13
Dept. of Transportation	97	94	66	69	69	63	59	58	75	95	90	106
Environmental Protection Agency	273	223	211	146	132	158	157	208	198	176	183	179
National Aeronautics & Space Admin	1,240	940	871	890	882	926	1,006	1,064	1,002	1,153	1,080	1,260
National Science Foundation	69	63	57	60	65	75	68	84	82	85	75	79
All other agencies	507	506	508	519	521	502	454	426	391	461	518	505

(continued)

Appendix table 4-8.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980-91

(page 4 of 4)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991(est.)
Development												
Millions of constant 1982 dollars[1]												
Total, all agencies	21,516	22,414	23,410	23,465	25,183	28,894	30,487	31,612	31,480	32,065	32,765	29,288
Dept. of Agriculture	36	35	31	29	29	29	28	25	25	28	39	40
Dept. of Commerce	104	84	60	48	57	67	52	54	39	37	28	45
Dept. of Defense	13,829	14,922	17,670	18,967	20,634	23,870	25,946	27,013	26,457	26,764	26,668	22,886
Dept. of Education	61	55	58	34	32	30	22	22	25	29	28	34
Dept. of Energy	4,102	3,760	3,012	2,471	2,448	2,533	2,312	2,253	2,303	2,178	2,273	2,249
Dept. of Health & Human Services	528	467	335	318	337	379	409	495	544	642	692	740
National Institutes of Health	465	413	309	298	321	358	365	454	502	566	586	594
Dept. of Housing & Urban Develop	43	34	19	20	11	11	9	9	10	9	9	14
Dept. of the Interior	67	61	30	24	28	20	15	18	20	21	26	29
Dept. of Labor	120	4	8	2	0	1	1	1	7	10	3	3
Dept. of Transportation	329	351	243	264	343	321	277	217	175	144	187	195
Environmental Protection Agency	118	115	92	63	82	95	87	60	66	84	79	60
National Aeronautics & Space Admin	1,917	2,345	1,671	1,071	1,028	1,384	1,180	1,286	1,644	1,984	2,635	2,885
National Science Foundation	10	7	2	0	0	0	0	0	0	0	0	0
All other agencies	253	174	180	153	153	155	149	160	166	133	97	107
R&D plant												
Total, all agencies	1,836	1,594	1,390	1,245	1,652	1,633	1,344	1,564	1,691	2,341	1,809	2,468
Dept. of Agriculture	67	22	21	32	36	36	69	95	111	98	73	110
Dept. of Commerce	5	1	1	1	9	4	8	4	9	13	11	14
Dept. of Defense	246	298	291	300	489	476	250	404	358	485	393	370
Dept. of Education	0	0	0	0	0	1	6	18	4	7	7	5
Dept. of Energy	1,208	1,050	914	727	788	779	648	654	752	823	770	895
Dept. of Health & Human Services	36	25	25	46	29	38	33	31	16	103	66	178
National Institutes of Health	35	24	19	17	26	26	26	30	16	103	64	169
Dept. of Housing & Urban Develop	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	9	4	1	2	5	4	4	10	8	9	9	11
Dept. of Labor	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of Transportation	27	20	12	21	16	8	11	9	11	15	17	15
Environmental Protection Agency	0	0	0	0	0	0	0	0	0	0	0	10
National Aeronautics & Space Admin	188	124	114	97	226	210	240	262	352	673	399	690
National Science Foundation	22	16	2	3	42	66	46	52	47	94	48	150
All other agencies	27	34	10	16	13	11	29	24	26	21	18	22
R&D and R&D plant												
Total, all agencies	37,038	37,111	37,822	38,385	40,680	44,992	46,242	48,377	48,506	50,791	51,038	49,150
Dept. of Agriculture	879	853	819	846	837	882	880	898	947	917	917	999
Dept. of Commerce	410	353	337	322	340	361	357	345	329	327	340	397
Dept. of Defense	16,744	18,010	20,913	22,359	23,941	27,187	29,014	30,253	29,478	30,134	29,745	25,932
Dept. of Education	165	113	128	107	107	113	112	130	116	133	129	153
Dept. of Energy	6,818	6,326	5,622	5,079	5,108	5,231	4,742	4,685	4,893	4,920	4,976	5,295
Dept. of Health & Human Services	4,497	4,239	3,965	4,222	4,494	4,925	4,974	5,630	5,902	6,339	6,494	6,960
National Institutes of Health	3,789	3,600	3,453	3,652	3,961	4,354	4,397	4,989	5,188	5,450	5,478	5,773
Dept. of Housing & Urban Develop	66	52	29	31	17	17	13	14	15	14	14	22
Dept. of the Interior	494	462	382	369	385	355	340	352	351	380	396	436
Dept. of Labor	163	67	25	19	15	12	9	18	30	28	21	21
Dept. of Transportation	454	466	322	355	430	393	347	284	261	254	294	316
Environmental Protection Agency	407	349	335	231	241	287	277	295	285	300	318	319
National Aeronautics & Space Admin	4,004	3,979	3,192	2,651	2,834	3,193	3,227	3,471	3,912	4,928	5,356	6,090
National Science Foundation	1,063	1,047	977	1,022	1,154	1,272	1,228	1,298	1,307	1,412	1,315	1,478
All other agencies	875	795	775	773	779	763	721	705	679	707	723	732

NOTE: Data for 1990 and 1991 are from the Administration's 1992 budget proposal; they differ from the figures in appendix tables 4-9 through 4-13.

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation (NSF), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington DC: NSF, 1990); NSF, unpublished tabulations; and Office of Management and Budget, unpublished tabulations.

See figures 4-4 and 4-5 and figure O-5 in Overview.

Appendix table 4-9.
Federal obligations to intramural performers for total R&D and basic research, by selected agency: FYs 1980-91

	All agencies	Dept. of Defense	National Institutes of Health	National Aero & Space Admin.	National Science Foundation	Dept. of Agriculture	Dept. of Energy	Dept. of Commerce	Dept. of Interior	All other agencies
Total research and development										
Millions of current dollars										
1980	7,632	3,796	587	965	75	457	474	226	242	810
1981	8,426	4,281	639	1,044	106	511	451	237	274	883
1982	9,141	5,139	709	1,166	118	531	176	242	261	799
1983	10,582	6,401	769	1,134	131	559	258	252	274	804
1984	11,572	7,257	830	1,043	136	589	216	256	334	911
1985	12,945	8,324	874	1,171	143	628	224	280	342	959
1986	13,535	8,881	958	1,217	130	630	206	285	332	896
1987	13,413	8,336	1,000	1,414	143	649	248	320	355	948
1988	14,281	9,046	1,092	1,335	162	694	245	316	353	1,038
1989	15,121	9,296	1,171	1,733	166	689	248	325	394	1,099
1990 (est.)	16,094	9,467	1,339	2,052	175	736	362	336	425	1,202
1991 (est.)	16,396	8,988	1,402	2,573	187	776	427	349	435	1,259
Basic research										
1980	1,182	199	320	225	68	180	6	13	62	109
1981	1,302	226	335	216	99	202	6	15	69	134
1982	1,466	246	405	251	112	219	7	16	65	145
1983	1,690	276	449	305	126	239	18	18	84	175
1984	1,861	303	479	345	130	274	11	19	110	190
1985	1,961	301	543	318	138	296	21	21	117	206
1986	2,018	308	579	363	126	293	25	23	111	189
1987	2,046	283	568	379	138	302	35	22	119	199
1988	2,050	263	592	343	154	322	33	27	108	208
1989	2,371	292	695	454	157	324	49	25	159	208
1990 (est.)	2,573	284	794	503	165	345	49	26	168	216
1991 (est.)	2,782	310	851	559	176	365	46	29	174	239

NOTE: Intramural activities cover costs associated with the planning and administration of intramural and extramural R&D programs by Federal personnel as well as actual intramural R&D performance.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327 Final (Washington, DC: NSF, 1991).

Science & Engineering Indicators – 1991

Appendix table 4-10.

Estimated Federal obligations for R&D, by selected agency, performer, and character of work: FY 1991

Agency	Total	Federal intramural	Industry	FFRDCs admin. by industry	Univers. and colleges	FFRDCs admin. by U&C	Other non-profits	FFRDCs admin. by nonprofits	State & local gov't	Foreign
Total research & development										
	Millions of current dollars									
Total, all agencies	66,107	16,396	31,512	2,062	9,191	3,654	2,302	482	184	325
Dept. of Agriculture	1,158	776	6	0	364	0	6	0	2	3
Dept. of Defense	36,918	8,988	25,353	287	1,069	624	110	313	1	172
Dept. of Energy	6,006	428	964	1,710	429	2,164	165	142	1	4
Dept. of Health & Human Services	8,888	1,879	398	19	4,946	33	1,428	11	115	59
Nat'l Aeronautics & Space Admin.	8,322	2,573	4,263	0	533	701	230	3	5	12
National Science Foundation	1,983	187	90	1	1,478	111	115	0	2	0
All other agencies	2,837	1,565	437	45	372	21	248	14	58	75
Basic research										
Total, all agencies	12,255	2,782	1,043	194	5,721	1,267	1,077	68	51	52
Dept. of Agriculture	547	365	*	0	176	*	3	0	1	2
Dept. of Defense	972	310	88	1	529	8	24	*	0	12
Dept. of Energy	1,677	46	42	180	307	899	141	61	*	1
Dept. of Health & Human Services	4,940	989	201	10	2,892	21	744	4	46	33
Nat'l Aeronautics & Space Admin.	1,803	559	593	0	367	227	50	2	1	4
National Science Foundation	1,853	176	76	1	1,382	111	106	*	2	0
All other agencies	463	337	43	2	68	1	9	1	1	*
Applied research										
Total, all agencies	10,965	4,084	2,384	311	2,635	596	720	70	74	90
Dept. of Agriculture	570	373	6	0	186	0	3	0	1	1
Dept. of Defense	2,497	1,027	1,079	24	260	49	38	9	1	9
Dept. of Energy	1,064	175	118	239	109	363	18	42	1	1
Dept. of Health & Human Services	3,037	713	153	6	1,621	9	463	6	45	21
Nat'l Aeronautics & Space Admin.	1,970	831	811	0	109	157	56	*	1	3
National Science Foundation	130	11	14	*	96	*	9	0	*	0
All other agencies	1,697	954	203	42	254	18	133	13	25	55
Development										
Total, all agencies	42,888	9,530	28,084	1,557	835	1,791	505	345	59	183
Dept. of Agriculture	41	38	0	0	2	0	*	0	*	*
Dept. of Defense	33,449	7,651	24,186	262	280	567	48	304	*	151
Dept. of Energy	3,265	207	804	1,291	13	902	6	39	*	2
Dept. of Health & Human Services	911	177	44	3	433	3	221	1	24	5
Nat'l Aeronautics & Space Admin.	4,549	1,183	2,859	0	57	317	124	1	3	5
National Science Foundation	0	0	0	0	0	0	0	0	0	0
All other agencies	637	274	191	1	50	2	106	0	32	20

* = less than $500,000

NOTES: These figures reflect funding levels as reported by Federal agencies in March through October 1990. They differ from the figures in appendix table 4-8, which reflect subsequent Congressional appropriation actions through January 1991. FFRDCs = federally funded research and development centers; U&C = universities and colleges.

SOURCE: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327 Final (Washington, DC: NSF, 1991).

See text table 4-2.

Science & Engineering Indicators – 1991

Appendix table 4-11.

Federal obligations for R&D, by character of work and performer: FYs 1980-91

(page 1 of 2)

Performer	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of current dollars											
TOTAL RESEARCH AND DEVELOPMENT	29,830	33,104	36,433	38,712	42,225	48,360	51,412	55,255	56,935	61,405	62,320	66,107
Federal intramural[1]	7,632	8,426	9,141	10,582	11,572	12,945	13,535	13,413	14,281	15,121	16,094	16,396
Industrial firms excluding FFRDCs	12,969	14,868	17,192	17,148	18,753	21,969	24,509	26,752	26,719	28,548	28,854	31,512
FFRDCs administered by industry	1,408	1,414	1,506	1,501	1,608	1,791	1,697	1,860	1,911	1,960	2,054	2,062
Universities and colleges excluding FFRDCs	4,263	4,466	4,606	4,966	5,565	6,358	6,579	7,354	7,828	8,672	8,748	9,191
FFRDCs administered by universities/colleges	1,533	1,791	1,977	2,266	2,325	2,535	2,440	3,210	3,474	3,497	3,410	3,654
Nonprofit institutions excluding FFRDCs	1,106	1,069	1,092	1,242	1,497	1,699	1,676	1,711	1,683	1,999	2,184	2,302
FFRDCs administered by nonprofit institutions	442	525	521	581	597	689	553	511	506	521	445	482
State and local governments	266	222	184	186	131	129	128	148	142	168	175	184
Foreign	211	323	214	240	176	245	296	298	392	919	357	325
Basic research	4,674	5,041	5,482	6,260	7,067	7,819	8,153	8,944	9,623	10,602	11,348	12,255
Federal intramural[1]	1,183	1,302	1,466	1,690	1,861	1,923	2,019	2,046	2,173	2,371	2,573	2,782
Industrial firms excluding FFRDCs	325	293	271	306	394	408	545	467	583	773	959	1,043
FFRDCs administered by industry	70	73	87	83	91	123	118	120	135	167	176	194
Universities and colleges excluding FFRDCs	2,320	2,503	2,727	3,112	3,531	4,039	4,132	4,666	4,927	5,221	5,377	5,721
FFRDCs administered by universities/colleges	437	491	517	591	653	696	691	907	1,009	1,098	1,146	1,267
Nonprofit institutions excluding FFRDCs	280	313	356	410	474	556	572	658	713	839	963	1,077
FFRDCs administered by nonprofit institutions	8	9	9	8	8	12	13	13	14	42	55	68
State and local governments	24	27	25	32	28	31	31	38	40	44	48	51
Foreign	28	31	25	29	28	31	33	30	30	47	50	52
Applied research	6,923	7,172	7,541	7,993	7,911	8,315	8,349	8,999	9,241	10,163	10,335	10,965
Federal intramural[1]	2,484	2,732	2,729	3,020	2,904	3,133	3,142	3,392	3,452	3,611	3,765	4,084
Industrial firms excluding FFRDCs	1,752	1,665	1,886	1,847	1,792	1,751	1,835	1,982	1,975	2,102	2,203	2,384
FFRDCs administered by industry	241	278	400	440	405	363	365	314	314	353	343	311
Universities and colleges excluding FFRDCs	1,379	1,417	1,318	1,356	1,499	1,688	1,751	1,975	2,124	2,572	2,496	2,635
FFRDCs administered by universities/colleges	414	450	540	621	635	641	502	564	593	605	587	596
Nonprofit institutions excluding FFRDCs	399	392	388	427	449	489	490	550	576	681	722	720
FFRDCs administered by nonprofit institutions	64	59	95	77	79	85	76	77	71	67	66	70
State and local governments	127	103	101	105	60	59	60	53	53	78	79	74
Foreign	63	75	83	101	89	107	130	94	83	95	75	90
Development	18,233	20,891	23,410	24,458	27,246	32,226	34,910	37,313	39,648	40,640	40,637	42,888
Federal intramural[1]	3,966	4,392	4,947	5,872	6,808	7,889	8,375	7,975	8,889	9,139	9,756	9,530
Industrial firms excluding FFRDCs	10,892	12,910	15,036	14,995	16,567	19,810	22,129	24,303	25,676	25,673	25,692	28,084
FFRDCs administered by industry	1,097	1,063	1,019	979	1,112	1,305	1,215	1,426	1,439	1,440	1,534	1,557
Universities and colleges excluding FFRDCs	564	546	560	499	535	631	696	713	720	879	875	835
FFRDCs administered by universities/colleges	682	850	920	1,054	1,037	1,198	1,247	1,739	1,770	1,794	1,677	1,791
Nonprofit institutions excluding FFRDCs	427	364	348	405	575	654	614	503	512	479	498	505
FFRDCs administered by nonprofit institutions	370	458	416	496	510	592	463	421	430	412	323	345
State and local governments	115	93	58	49	43	40	37	58	55	46	48	59
Foreign	120	218	106	110	59	107	134	173	159	777	233	183

(continued)

Appendix table 4-11.

Federal obligations for R&D, by character of work and performer: FYs 1980-91

(page 2 of 2)

Performer	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of constant 1982 dollars[2]											
TOTAL RESEARCH AND DEVELOPMENT	35,202	35,517	36,433	37,140	39,028	43,359	44,898	46,813	46,815	48,450	47,275	48,023
Federal intramural[1]	9,007	9,040	9,141	10,152	10,696	11,607	11,820	11,364	11,742	11,931	12,209	11,911
Industrial firms excluding FFRDCs	15,304	15,952	17,192	16,451	17,333	19,697	21,403	22,665	21,970	22,525	21,888	22,892
FFRDCs administered by industry	1,662	1,517	1,506	1,440	1,487	1,606	1,482	1,576	1,571	1,546	1,558	1,498
Universities and colleges excluding FFRDCs	5,031	4,791	4,606	4,765	5,144	5,700	5,746	6,230	6,437	6,842	6,636	6,677
FFRDCs administered by universities/colleges	1,809	1,922	1,977	2,174	2,149	2,273	2,131	2,719	2,856	2,759	2,587	2,654
Nonprofit institutions excluding FFRDCs	1,305	1,147	1,092	1,191	1,384	1,523	1,463	1,449	1,384	1,577	1,657	1,672
FFRDCs administered by nonprofit institutions	521	563	521	558	552	618	483	433	416	411	338	350
State and local governments	313	238	184	178	121	116	112	126	117	133	133	134
Foreign	249	347	214	230	162	219	259	252	322	725	271	236
Basic research	5,516	5,409	5,482	6,006	6,532	7,010	7,120	7,578	7,912	8,365	8,608	8,903
Federal intramural[1]	1,395	1,397	1,466	1,621	1,720	1,725	1,763	1,734	1,787	1,871	1,952	2,021
Industrial firms excluding FFRDCs	384	314	271	293	364	366	476	396	479	610	727	758
FFRDCs administered by industry	83	79	87	80	84	110	103	102	111	132	134	141
Universities and colleges excluding FFRDCs	2,738	2,686	2,727	2,986	3,263	3,621	3,609	3,953	4,051	4,119	4,079	4,156
FFRDCs administered by universities/colleges	515	526	517	567	603	624	604	768	829	866	869	920
Nonprofit institutions excluding FFRDCs	330	336	356	393	438	498	500	557	586	662	731	782
FFRDCs administered by nonprofit institutions	9	9	9	8	8	11	11	11	11	33	42	49
State and local governments	28	28	25	31	26	27	27	32	33	35	36	37
Foreign	33	33	25	27	26	28	29	26	25	37	38	38
Applied research	8,170	7,694	7,541	7,669	7,312	7,455	7,291	7,624	7,599	8,019	7,840	7,965
Federal intramural[1]	2,931	2,932	2,729	2,898	2,684	2,809	2,743	2,873	2,839	2,849	2,856	2,967
Industrial firms excluding FFRDCs	2,068	1,787	1,886	1,772	1,656	1,570	1,602	1,679	1,624	1,658	1,671	1,732
FFRDCs administered by industry	284	298	400	422	375	326	318	266	258	279	260	226
Universities and colleges excluding FFRDCs	1,627	1,520	1,318	1,301	1,385	1,513	1,529	1,673	1,747	2,029	1,893	1,914
FFRDCs administered by universities/colleges	489	483	540	595	587	574	438	478	487	477	445	433
Nonprofit institutions excluding FFRDCs	471	421	388	410	415	439	428	466	474	537	548	523
FFRDCs administered by nonprofit institutions	76	63	95	74	73	76	66	65	58	53	50	51
State and local governments	150	110	101	100	55	53	52	45	44	62	60	54
Foreign	74	80	83	97	82	96	113	80	68	75	57	65
Development	21,516	22,414	23,410	23,465	25,183	28,894	30,487	31,612	32,601	32,065	30,827	31,156
Federal intramural[1]	4,680	4,712	4,947	5,633	6,292	7,074	7,313	6,757	7,309	7,211	7,401	6,923
Industrial firms excluding FFRDCs	12,853	13,851	15,036	14,386	15,313	17,761	19,325	20,590	21,112	20,256	19,490	20,401
FFRDCs administered by industry	1,295	1,140	1,019	939	1,028	1,170	1,061	1,208	1,183	1,136	1,164	1,131
Universities and colleges excluding FFRDCs	666	585	560	478	495	566	608	604	592	694	664	607
FFRDCs administered by universities/colleges	805	912	920	1,011	959	1,074	1,089	1,473	1,455	1,415	1,272	1,301
Nonprofit institutions excluding FFRDCs	504	390	348	388	531	586	536	426	421	378	378	367
FFRDCs administered by nonprofit institutions	437	491	416	476	471	531	405	357	353	325	245	251
State and local governments	135	100	58	47	40	36	33	49	45	36	36	43
Foreign	142	233	106	105	55	96	117	147	131	613	177	133

NOTE: FFRDCs = Federally funded research and development centers.

[1] Federal intramural activities cover costs associated with administering intramural and extramural programs by Federal personnel and actual intramural performance.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327 Final (Washington, DC: NSF, 1991).

Appendix table 4-12.

Federal obligations for basic research, by science and engineering field: FYs 1980-91

(page 1 of 3)

Science and engineering field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of current dollars											
Total, all fields	4,674	5,041	5,482	6,260	7,067	7,819	8,153	8,944	9,474	10,602	11,348	12,255
Life sciences	2,054	2,224	2,526	2,891	3,288	3,787	3,859	4,364	4,502	4,916	5,203	5,589
Biological & agricultural, total	1,340	1,462	1,675	1,929	2,175	2,516	2,543	2,870	2,856	3,102	3,291	3,565
Biological (excl. environmental)	1,100	1,202	1,401	1,622	1,836	2,106	2,152	2,462	2,415	2,647	2,804	3,040
Environmental biology	86	83	83	93	121	126	126	141	147	157	168	178
Agricultural	154	177	190	214	218	284	266	268	294	298	319	347
Medical sciences, total	657	706	793	879	1,015	1,145	1,197	1,343	1,573	1,708	1,801	1,906
Other life sciences	58	55	58	84	98	126	119	151	73	104	111	119
Psychology	84	91	90	93	108	133	133	147	188	187	202	221
Physical sciences	1,221	1,325	1,394	1,587	1,728	1,815	1,914	2,096	2,200	2,506	2,697	2,966
Astronomy	279	274	271	355	380	401	453	505	459	525	556	577
Chemistry	257	298	312	362	403	425	433	445	471	505	532	545
Physics	668	735	791	855	921	960	1,003	1,072	1,206	1,395	1,520	1,699
Other physical sciences	16	17	20	15	24	30	25	74	65	82	87	146
Environmental sciences	522	533	520	580	657	700	749	781	873	1,017	1,184	1,328
Atmospheric science	179	174	163	173	192	209	240	244	281	316	399	496
Geological	198	194	178	178	198	250	266	266	267	335	371	383
Oceanography	131	143	155	196	220	219	224	250	269	294	317	373
Other environmental sciences	14	22	25	34	46	21	19	21	55	72	98	77
Mathematics & computer sciences	116	140	165	208	241	260	293	306	313	346	356	379
Mathematics	67	79	91	101	114	130	142	158	165	168	171	186
Computer sciences	46	52	67	90	105	116	131	129	125	160	161	173
Other math & computer sciences	3	9	7	17	22	14	20	20	22	18	24	20
Social sciences	147	137	120	138	133	141	114	130	147	155	188	189
Anthropology	14	13	13	11	17	16	11	12	12	12	13	14
Economics	40	34	39	41	30	34	26	29	35	38	46	44
Political science	7	6	4	5	4	6	4	6	5	5	6	6
Sociology	25	23	19	33	34	32	30	34	37	38	54	81
Other social sciences	60	61	45	48	48	52	42	48	58	61	69	43
Other sciences	64	65	56	73	69	100	122	131	255	292	319	328

(continued)

Appendix table 4-12.

Federal obligations for basic research, by science and engineering field: FYs 1980-91

(page 2 of 3)

Science and engineering field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
						Millions of current dollars						
Engineering	465	526	611	690	845	884	969	990	1,006	1,184	1,199	1,253
Aeronautical	104	113	127	141	226	192	226	237	231	328	337	299
Astronautical	27	33	45	50	52	42	53	49	48	59	64	87
Chemical	26	31	35	50	56	74	73	78	89	50	58	64
Civil	22	23	32	32	42	44	45	46	46	52	50	55
Electrical	71	79	94	96	130	145	156	175	154	174	165	180
Mechanical	42	47	53	61	64	88	84	87	84	101	100	109
Metallurgy & materials	121	139	156	183	187	212	229	210	230	255	266	300
Other	52	61	69	76	88	88	103	108	124	166	158	159
						Millions of constant 1982 dollars[1]						
Total, all fields	5,516	5,409	5,482	6,006	6,532	7,010	7,120	7,578	7,790	8,365	8,608	8,903
Life sciences	2,424	2,386	2,526	2,774	3,039	3,395	3,370	3,697	3,702	3,879	3,947	4,060
Biological & agricultural, total	1,581	1,569	1,675	1,850	2,010	2,255	2,221	2,432	2,348	2,447	2,496	2,590
Biological (excl. environmental)	1,298	1,289	1,401	1,556	1,697	1,888	1,879	2,085	1,986	2,089	2,127	2,208
Environmental biology	102	89	83	89	112	113	110	119	121	124	127	129
Agricultural	181	190	190	206	202	254	232	227	242	235	242	252
Medical sciences, total	775	758	793	843	938	1,027	1,045	1,138	1,293	1,348	1,366	1,385
Other life sciences	68	59	58	80	90	113	104	128	60	82	84	86
Psychology	99	98	90	89	100	119	116	125	155	148	153	161
Physical sciences	1,440	1,421	1,394	1,523	1,597	1,628	1,672	1,776	1,809	1,977	2,046	2,155
Astronomy	330	294	271	340	351	359	396	427	377	414	422	419
Chemistry	303	320	312	347	373	381	378	377	387	398	404	396
Physics	789	789	791	820	852	861	876	908	992	1,101	1,153	1,234
Other physical sciences	19	18	20	15	22	27	22	63	53	65	66	106
Environmental sciences	616	572	520	557	607	627	654	662	718	802	898	965
Atmospheric science	211	186	163	166	178	188	210	207	231	249	303	360
Geological	234	208	178	171	183	224	232	226	220	264	281	278
Oceanography	154	154	155	188	203	197	196	212	221	232	240	271
Other environmental sciences	17	23	25	32	43	19	17	18	45	57	74	56
Mathematics & computer sciences	137	151	165	200	223	233	256	260	257	273	270	275
Mathematics	79	85	91	97	105	117	124	134	136	133	130	135
Computer sciences	55	56	67	87	97	104	115	109	103	126	122	126
Other math & computer sciences	4	10	7	16	21	12	17	17	18	14	18	15

(continued)

Appendix table 4-12.

Federal obligations for basic research, by science and engineering field: FYs 1980-91

(page 3 of 3)

Science and engineering field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of constant 1982 dollars[1]											
Social sciences	174	147	120	132	123	126	99	110	121	122	143	137
Anthropology	17	14	13	11	16	14	10	10	10	9	10	10
Economics	47	37	39	39	27	31	23	25	29	30	35	32
Political science	9	7	4	4	4	5	4	5	4	4	5	4
Sociology	30	24	19	31	31	29	26	29	30	30	41	59
Other social sciences	71	65	45	46	44	47	37	41	48	48	52	31
Other sciences	75	70	56	70	64	89	107	111	210	230	242	238
Engineering	549	564	611	662	781	793	846	838	827	934	910	910
Aeronautical	123	122	127	135	208	172	198	201	190	259	256	217
Astronautical	32	36	45	48	48	37	46	41	39	47	49	63
Chemical	31	34	35	48	51	67	64	66	73	39	44	46
Civil	26	25	32	31	39	39	39	39	38	41	38	40
Electrical	83	84	94	92	121	130	136	149	127	137	125	131
Mechanical	50	51	53	58	59	79	73	74	69	80	76	79
Metallurgy & materials	143	149	156	175	173	190	200	178	189	201	202	218
Other	61	65	69	73	81	79	90	91	102	131	120	116

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327 Final (Washington, DC: NSF, 1991).

See figure 4-6.

Science & Engineering Indicators – 1991

Appendix table 4-13.

Federal obligations for applied research, by science and engineering field: FYs 1980-91

(page 1 of 3)

Science and engineering field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of current dollars											
Total, all fields	6,923	7,172	7,541	7,993	7,911	8,315	8,349	8,999	9,176	10,163	10,335	10,965
Life sciences	2,138	2,212	2,220	2,287	2,348	2,576	2,606	2,980	3,223	3,579	3,710	3,818
Biological & agricultural, total	1,168	1,249	1,137	1,136	1,150	1,240	1,318	1,488	1,718	1,917	1,982	2,060
Biological (excl. environmental)	731	795	678	684	727	779	842	1,041	1,267	1,336	1,444	1,480
Environmental biology	144	137	100	101	129	135	138	149	154	210	187	192
Agricultural	294	317	359	351	294	326	338	299	297	371	352	387
Medical sciences, total	880	904	980	1,049	1,098	1,223	1,164	1,324	1,368	1,514	1,572	1,600
Other life sciences	90	59	103	102	100	113	123	168	137	148	156	158
Psychology	115	118	129	148	159	194	201	222	212	235	246	288
Physical sciences	780	896	1,107	1,304	1,241	1,231	1,155	1,157	1,118	1,199	1,198	1,225
Astronomy	6	7	5	3	3	14	15	18	12	17	25	23
Chemistry	198	189	169	158	203	225	229	235	232	278	307	288
Physics	514	610	820	1,000	915	856	803	781	770	795	767	780
Other physical sciences	62	90	113	144	120	135	108	122	103	108	100	134
Environmental sciences	739	588	628	671	619	704	733	731	734	756	920	1,017
Atmospheric science	231	200	263	288	242	277	281	309	307	272	339	416
Geological	203	202	180	155	161	179	178	176	174	208	220	213
Oceanography	131	118	107	148	143	179	205	178	191	198	209	210
Other environmental sciences	173	68	79	80	73	69	68	68	62	78	152	178
Mathematics & computer sciences	125	139	185	211	200	315	322	334	330	390	365	413
Mathematics	24	39	37	33	37	53	42	46	52	68	65	69
Computer sciences	82	69	104	124	110	164	171	169	167	205	178	214
Other math & computer sciences	18	31	44	55	53	97	109	119	110	116	122	131
Social sciences	377	361	266	298	304	319	302	351	339	396	433	457
Anthropology	3	2	2	2	2	2	2	3	2	2	2	2
Economics	153	173	118	125	118	125	105	120	125	129	134	143
Political science	5	5	3	7	7	9	8	6	7	8	6	6
Sociology	46	42	33	35	36	34	37	40	45	56	68	73
Other social sciences	170	140	110	130	141	149	150	183	160	202	222	233
Other sciences	286	314	231	247	262	242	261	307	271	350	301	316

(continued)

Appendix table 4-13.

Federal obligations for applied research, by science and engineering field: FYs 1980-91

(page 2 of 3)

Science and engineering field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of current dollars											
Engineering	2,365	2,545	2,776	2,828	2,779	2,733	2,770	2,917	2,950	3,258	3,162	3,431
Aeronautical	604	596	615	680	635	547	549	573	571	659	727	777
Astronautical	275	271	246	271	344	383	474	576	527	619	548	716
Chemical	70	116	60	95	89	180	175	138	169	92	95	98
Civil	137	136	170	156	161	173	158	159	169	178	185	195
Electrical	447	478	519	519	500	482	518	611	577	669	535	536
Mechanical	166	157	148	206	126	179	153	146	157	157	163	179
Metallurgy & materials	115	118	153	150	154	227	217	152	227	266	254	299
Other	552	673	866	751	770	563	529	562	553	619	656	631
	Millions of constant 1982 dollars											
Total, all fields	8,170	7,694	7,541	7,669	7,312	7,455	7,291	7,624	7,545	8,019	7,840	7,965
Life sciences	2,523	2,373	2,220	2,194	2,171	2,310	2,275	2,525	2,650	2,824	2,814	2,774
Biological & agricultural, total	1,378	1,340	1,137	1,089	1,063	1,112	1,151	1,261	1,413	1,513	1,504	1,496
Biological (excl. environmental)	862	853	678	656	672	699	735	882	1,042	1,054	1,095	1,075
Environmental biology	169	147	100	97	119	121	121	126	127	166	142	139
Agricultural	347	341	359	337	272	292	295	253	244	293	267	281
Medical sciences, total	1,038	970	980	1,006	1,014	1,097	1,016	1,122	1,125	1,195	1,192	1,162
Other life sciences	106	63	103	98	93	101	108	142	113	117	118	115
Psychology	135	126	129	142	147	174	176	188	174	185	187	209
Physical sciences	920	961	1,107	1,251	1,147	1,104	1,008	980	919	946	909	890
Astronomy	7	7	5	3	2	13	13	15	10	13	19	17
Chemistry	233	202	169	152	188	202	200	199	191	219	233	209
Physics	607	655	820	959	846	768	701	662	633	627	582	567
Other physical sciences	73	96	113	138	111	121	94	104	85	85	76	97
Environmental sciences	872	631	628	644	572	631	640	619	604	596	698	739
Atmospheric science	272	214	263	276	224	248	245	262	252	215	257	302
Geological	240	217	180	149	149	160	156	149	143	164	167	155
Oceanography	155	127	107	142	133	161	179	150	157	156	159	153
Other environmental sciences	205	73	79	77	67	62	59	58	51	62	115	129
Mathematics & computer sciences	147	149	185	203	184	282	281	283	271	308	277	300
Mathematics	28	41	37	31	34	48	37	39	43	54	49	50
Computer sciences	97	74	104	119	101	147	149	143	137	162	135	155
Other math & computer sciences	21	33	44	52	49	87	95	101	90	92	93	95

(continued)

Appendix table 4-13.

Federal obligations for applied research, by science and engineering field: FYs 1980-91

(page 3 of 3)

Science and engineering field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of constant 1982 dollars[1]											
Social sciences	444	387	266	285	281	286	264	297	279	312	328	332
Anthropology	3	2	2	2	2	2	2	2	2	2	2	1
Economics	180	185	118	120	109	112	92	101	103	102	102	104
Political science	6	5	3	6	6	8	7	5	6	6	5	4
Sociology	54	45	33	34	34	30	32	34	37	44	52	53
Other social sciences	201	150	110	125	131	134	131	155	132	159	168	169
Other sciences	337	336	231	237	242	217	228	260	223	276	228	230
Engineering	2,791	2,731	2,776	2,713	2,569	2,451	2,419	2,471	2,426	2,571	2,399	2,492
Aeronautical	713	640	615	652	587	490	480	485	470	520	551	564
Astronautical	325	291	246	260	318	344	414	488	433	488	416	520
Chemical	83	125	60	91	82	161	151	117	139	73	72	71
Civil	161	146	170	150	149	155	138	134	139	140	140	142
Electrical	527	513	519	498	462	432	452	518	474	528	406	389
Mechanical	196	169	148	197	117	160	134	124	129	124	124	130
Metallurgy & materials	135	126	153	144	142	204	189	129	187	210	193	217
Other	651	722	866	721	712	505	462	476	455	488	498	458

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327, Final (Washington, DC: NSF, 1991).

See figure 4-6.

Appendix table 4-14.
Small Business Innovation Research (SBIR) awards, by award type and selected agency: FYs 1983-89

Award type and agency	1983	1984	1985	1986	1987	1988	1989
	Millions of current dollars						
Total[1]	45	108	199	298	351	389	432
By type							
Phase I awards	45	48	69	99	110	102	108
Phase II awards	0	60	130	199	241	285	322
By agency							
Dept. of Agriculture	1	2	3	4	4	4	4
Dept. of Commerce	0	0	0	1	2	1	1
Dept. of Defense	20	45	78	151	194	208	233
Dept. of Education	*	1	1	2	2	2	2
Dept. of Energy	5	16	26	29	28	30	33
Dept. of Health & Human Services	7	23	45	57	67	73	79
Dept. of the Interior	*	1	*	0	0	0	0
Dept. of Transportation	*	2	3	4	3	3	4
Environmental Protection Agency	*	1	2	3	3	3	3
Nat'l Aeronautics & Space Admin	5	13	29	36	32	47	52
National Science Foundation	5	7	10	15	17	17	19
Nuclear Regulatory Commission	*	1	1	1	1	1	1
	Millions of constant 1982 dollars[2]						
Total[1]	43	100	178	260	297	320	341
By type							
Phase I awards	43	44	62	86	93	84	85
Phase II awards	0	56	117	174	204	234	254
By agency							
Dept. of Agriculture	1	2	3	3	3	3	3
Dept. of Commerce	0	0	0	1	1	1	1
Dept. of Defense	19	41	70	132	164	171	184
Dept. of Education	*	1	1	1	1	1	2
Dept. of Energy	5	15	23	25	24	25	26
Dept. of Health & Human Services	7	21	40	50	57	60	63
Dept. of the Interior	*	1	*	0	0	0	0
Dept. of Transportation	*	2	3	3	2	3	3
Environmental Protection Agency	*	1	2	2	3	2	2
Nat'l Aeronautics & Space Admin	5	12	26	31	27	39	41
National Science Foundation	5	6	9	13	14	14	15
Nuclear Regulatory Commission	*	1	1	1	1	*	1

* = less than $500,000

[1] Totals are SBIR award obligations that include award modifications. The details by type of award and agency do not necessarily contain subsequent year revisions and may not sum to totals.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Office of Innovation, Research, and Technology, Small Business Administration, *Small Business Innovation Development Act* (Washington, DC: SBA, ongoing series).

See figure 4-7.

Appendix table 4-15.

Small Business Innovation Research (SBIR) awards, by technology area and selected agency: FYs 1983-89 (cumulative)

Technology area[1]	Total	Dept. of Defense	Dept. of Energy	Dept. of Health & Human Svcs	Nat'l Aero & Space Admin.	National Science Foundation	Other[2]
				Percent			
Total (1983-89)	100	100	100	100	100	100	100
Computer, information, & analysis	22	26	10	15	26	18	19
Electronics	21	27	18	7	20	16	12
Materials	16	18	25	6	15	24	14
Mechanics of vehicles & facilities	7	10	4	1	12	4	4
Energy conservation and use	12	10	28	3	15	10	6
Environmental & natural resources	7	5	10	4	7	13	20
Life sciences	16	4	4	64	4	15	25
				Millions of current dollars			
Total (1983-89)	2,885	1,389	337	513	371	136	139

[1] Distributions are based on the cumulative 1983-89 value of awards, not on the number of awards granted. Within each of the broad technology areas listed, SBIR awards are assigned to more specific technology areas, including multiple technology areas. Therefore, the percentage distributions include overcounting of awards assigned to multiple technology areas.

[2] Includes Departments of Agriculture, Commerce, Education, and Transportation, the Environmental Protection Agency, and the Nuclear Regulatory Commission.

SOURCE: Office of Innovation, Research, and Technology, Small Business Administration, *Small Business Innovation Development Act: Seventh Year Results* (Washington, DC: SBA, 1990).

Science & Engineering Indicators – 1991

Appendix table 4-16.

Annual aggregate data on independent research and development (IR&D): FYs 1976-89

	Independent research and development						DOD and NASA R&D obligations		IR&D as a percentage of	
	Accepted by Government IR&D program					Not accepted under IR&D program			DOD and NASA R&D total[2] (a)	DOD and NASA R&D performed by industry[2] (b)
	Incurred by industry	Total accepted	DOD share	NASA share	Not reimbursed		Total	Total to industry[1]		
	Millions of current dollars								Percent	
1976	1,388	1,061	544	41	476	327	13,102	8,143	4.5	7.2
1977	1,560	1,199	598	46	555	361	14,134	9,109	4.6	7.1
1978	1,788	1,365	643	49	673	423	14,887	9,458	4.6	7.3
1979	2,104	1,517	708	54	755	587	16,084	10,079	4.7	7.6
1980	2,373	1,728	812	57	859	645	17,215	11,038	5.0	7.9
1981	2,796	2,039	1,056	66	917	757	20,102	13,028	5.6	8.6
1982	3,654	2,821	1,338	67	1,416	833	23,701	15,375	5.9	9.1
1983	4,017	2,961	1,601	78	1,282	1,056	25,654	15,700	6.5	10.7
1984	5,173	3,897	1,884	86	1,927	1,276	28,195	17,340	7.0	11.4
1985	5,036	3,500	2,099	88	1,313	1,536	33,119	20,645	6.6	10.6
1986	5,042	3,537	2,198	77	1,262	1,505	36,358	23,232	6.3	9.8
1987	4,885	3,544	2,186	67	1,291	1,341	39,019	25,721	5.8	8.8
1988	4,825	3,694	2,181	89	1,424	1,131	39,746	25,572	5.7	8.9
1989	4,831	3,770	2,226	105	1,439	1,061	42,970	27,469	5.4	8.5
	Millions of constant 1982 dollars[3]									
1976	2,236	1,709	876	66	767	527	21,104	13,116		
1977	2,327	1,789	892	69	828	539	21,086	13,589		
1978	2,493	1,903	897	68	938	590	20,757	13,188		
1979	2,701	1,947	909	69	969	754	20,649	12,939		
1980	2,800	2,039	958	67	1,014	761	20,315	13,025		
1981	3,000	2,188	1,133	71	984	812	21,567	13,977		
1982	3,654	2,821	1,338	67	1,416	833	23,701	15,375		
1983	3,854	2,841	1,536	75	1,230	1,013	24,613	15,063		
1984	4,781	3,602	1,741	79	1,781	1,179	26,060	16,027		
1985	4,515	3,138	1,882	79	1,177	1,377	29,694	18,510		
1986	4,403	3,089	1,919	67	1,102	1,314	31,751	20,288		
1987	4,139	3,003	1,852	57	1,094	1,136	33,057	21,792		
1988	3,967	3,037	1,793	73	1,171	930	32,681	21,027		
1989	3,812	2,975	1,756	83	1,135	837	33,904	21,673		

NOTE: DOD = Department of Defense; NASA = National Aeronautics and Space Administration.

[1] Includes R&D performed by federally funded research and development centers administered by the industrial sector.

[2] Percentages calculated as follows: numerator in (a) is total DOD and NASA IR&D reimbursements, and denominator is total DOD and NASA R&D, excluding IR&D; numerator in (b) is total DOD and NASA IR&D reimbursements, and denominator is DOD and NASA R&D performed by industry, excluding IR&D.

[3] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Defense Contract Audit Agency, *Summary of Independent Research and Development and Bid and Proposal Cost Incurred by Major Defense Contractors* (Washington, DC: DCAA, ongoing series); NASA, unpublished tabulations; Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington, DC: NSF, 1990); and SRS, *Selected Data on Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327(Washington, DC: NSF, December 1990).

See figure 4-8.

Appendix table 4-17.

Federal R&D funding, by budget function: FYs 1978-92

Function	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991 (est.)	1992 (est.)
	Millions of current dollars														
Total	25,976	28,208	29,739	33,735	36,115	38,768	44,214	49,887	53,249	57,069	59,106	62,115	63,781	64,123	72,057
National defense	12,899	13,791	14,946	18,413	22,070	24,936	29,287	33,698	36,926	39,152	40,099	40,665	39,925	37,788	43,247
Health	2,968	3,401	3,694	3,871	3,869	4,298	4,779	5,418	5,565	6,556	7,076	7,773	8,308	9,086	9,649
Space research and technology	2,939	3,136	2,738	3,111	2,584	2,134	2,300	2,725	2,894	3,398	3,683	4,555	5,765	6,428	7,656
General science	1,050	1,119	1,233	1,340	1,359	1,502	1,676	1,862	1,873	2,042	2,160	2,373	2,410	2,632	2,962
Energy	3,134	3,461	3,603	3,501	3,012	2,578	2,581	2,389	2,286	2,053	2,126	2,419	2,715	2,885	2,920
Natural resources and environment	904	1,010	999	1,061	965	952	963	1,059	1,062	1,133	1,160	1,255	1,386	1,553	1,602
Transportation	768	798	887	869	791	876	1,040	1,030	917	908	896	1,064	1,045	1,251	1,380
Agriculture	501	552	585	659	693	745	762	836	815	822	882	907	950	1,049	1,091
Education, training, employment, and social services	345	354	468	298	228	189	200	220	248	267	285	347	374	470	510
International affairs	57	117	125	160	165	177	192	210	211	223	224	279	375	385	413
Veterans benefits and services	111	123	126	143	139	157	218	193	183	215	195	212	216	219	219
Commerce and housing credit	77	93	101	106	104	107	110	114	111	110	122	128	140	175	200
Community and regional development	92	127	119	104	63	44	46	50	88	99	108	74	78	97	102
Administration of justice	44	47	45	34	31	37	24	47	41	49	51	45	44	47	53
Income security	67	57	47	43	32	32	26	21	14	25	23	27	33	40	35
General government	20	23	22	22	10	6	8	17	14	17	17	15	17	18	18
	Millions of constant 1982 dollars[1]														
Total	36,219	36,212	35,094	36,194	36,115	37,194	40,866	44,728	46,502	48,350	48,600	49,009	48,383	46,582	50,289
National defense	17,985	17,704	17,637	19,755	22,070	23,923	27,070	30,213	32,247	33,170	32,971	32,085	30,286	27,451	30,182
Health	4,138	4,366	4,359	4,153	3,869	4,123	4,417	4,858	4,860	5,554	5,818	6,133	6,302	6,600	6,734
Space research and technology	4,098	4,026	3,231	3,338	2,584	2,047	2,126	2,443	2,527	2,879	3,028	3,594	4,373	4,670	5,343
General science	1,464	1,437	1,455	1,438	1,359	1,441	1,549	1,669	1,636	1,730	1,776	1,872	1,828	1,912	2,067
Energy	4,370	4,443	4,252	3,756	3,012	2,473	2,386	2,142	1,996	1,739	1,748	1,909	2,060	2,096	2,038
Natural resources and environment	1,260	1,297	1,179	1,138	965	913	890	949	927	960	954	990	1,051	1,128	1,118
Transportation	1,071	1,024	1,047	932	791	840	961	923	801	769	737	840	793	909	963
Agriculture	699	709	690	707	693	715	704	750	712	696	725	716	721	762	761
Education, training, employment, and social services	481	454	552	320	228	181	185	197	217	226	234	274	284	341	356
International affairs	79	150	148	172	165	170	177	188	184	189	184	220	284	280	288
Veterans benefits and services	155	158	149	153	139	151	201	173	160	182	160	167	164	159	153
Commerce and housing credit	107	119	119	114	104	103	102	102	97	93	100	101	106	127	140
Community and regional development	128	163	140	112	63	42	43	45	77	84	89	58	59	70	71
Administration of justice	61	60	53	36	31	35	22	42	36	42	42	36	33	34	37
Income security	93	73	55	46	32	31	24	19	12	21	19	21	25	29	24
General government	28	30	26	24	10	6	7	15	12	14	14	12	13	13	13

NOTES: Data for 1978-90 are actual budget authority. Data for 1991 and 1992 are estimates based on the FY 1992 budget. Budget obligations for 1955-77 are available from the source document listed below.

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Science Resource Studies Division, National Science Foundation, *Selected Data on Federal R&D Funding by Budget Function: Fiscal Years 1990-92*, NSF 90-319 (Washington, DC: NSF, 1991).

See figures 4-9 and 4-10.

Appendix table 4-18.

Federal basic research funding, by budget function: FYs 1978-92

Function	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991 (est.)	1992 (est.)
	Millions of current dollars														
Total	3,665	4,108	4,716	5,107	5,305	6,247	7,072	7,810	8,193	9,021	9,553	10,648	11,288	12,330	13,294
Health	1,246	1,579	1,761	1,951	1,953	2,475	2,813	3,243	3,324	3,851	4,087	4,413	4,661	5,101	5,477
General science	962	1,026	1,152	1,256	1,296	1,439	1,606	1,779	1,795	1,942	2,061	2,265	2,306	2,517	2,826
Space research and technology	412	440	482	445	434	501	646	498	737	843	944	1,099	1,389	1,453	1,696
National defense	320	365	552	610	696	788	845	856	960	900	905	965	964	1,024	1,041
Energy	157	172	200	220	260	320	365	428	456	511	571	703	761	913	870
Agriculture	197	222	246	281	295	326	353	406	390	397	428	433	456	495	532
Natural resources and environment	207	131	136	131	139	156	192	206	204	206	210	331	336	392	386
Transportation	70	75	79	89	102	117	125	255	184	231	197	287	242	245	264
Education, training, employment, and social services	57	59	61	66	78	70	77	86	83	78	83	92	106	119	127
Commerce and housing credit	9	10	15	17	17	19	20	23	26	26	28	29	31	31	34
Veterans benefits and services	9	10	14	15	13	14	15	15	15	17	17	16	16	16	16
Administration of justice	10	10	9	5	4	4	5	4	5	8	8	7	9	6	6
Community and regional development	8	8	8	5	7	6	5	6	6	4	7	3	3	5	5
General government	0	*	*	3	2	3	3	4	5	4	5	3	3	4	4
International affairs	*	0	0	12	10	10	3	4	5	3	3	3	4	9	10
Income security	2	1	1	3	0	0	0	0	0	0	0	0	0	0	0
	Millions of constant 1982 dollars[1]														
Total	5,110	5,274	5,565	5,479	5,305	5,993	6,537	7,002	7,155	7,643	7,855	8,401	8,563	8,957	9,278
Health	1,737	2,027	2,078	2,093	1,953	2,374	2,600	2,908	2,903	3,263	3,361	3,482	3,536	3,706	3,822
General science	1,341	1,317	1,359	1,348	1,296	1,381	1,484	1,595	1,568	1,645	1,695	1,787	1,749	1,828	1,972
Space research and technology	574	565	569	477	434	481	597	447	644	714	776	867	1,054	1,056	1,184
National defense	446	469	651	654	696	756	781	767	838	762	744	761	731	744	727
Energy	219	221	236	236	260	307	337	384	398	433	470	555	577	663	607
Agriculture	275	285	290	301	295	313	326	364	341	336	352	342	346	360	371
Natural resources and environment	289	168	160	141	139	150	177	185	178	175	173	261	255	285	269
Transportation	98	96	93	95	102	112	116	229	161	196	162	226	184	178	184
Education, training, employment, and social services	79	76	72	71	78	67	71	77	72	66	68	73	80	86	89
Commerce and housing credit	13	13	18	18	17	18	18	21	23	22	23	23	24	23	24
Veterans benefits and services	13	13	17	16	13	13	14	13	13	14	14	13	12	12	11
Administration of justice	14	13	11	5	4	4	5	4	4	7	7	6	7	4	4
Community and regional development	11	10	9	5	7	6	5	5	5	3	6	2	2	4	3
General government	0	*	*	3	2	3	3	4	4	3	4	2	2	3	3
International affairs	*	0	0	13	10	10	3	4	4	3	2	2	3	7	7
Income security	3	1	1	3	0	0	0	0	0	0	0	0	0	0	0

* = less than $500,000

NOTES: Data for 1978-90 are actual budget authority. Data for 1991 and 1992 are estimates based on the FY 1992 budget. Budget obligations for 1955-77 are available from the source document listed below.

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Science Resource Studies Division, National Science Foundation, *Selected Data on Federal R&D Funding by Budget Function: Fiscal Years 1990-92*, NSF 90-319 (Washington, DC: NSF, 1991).

See figure 4-10.

Appendix table 4-19.
National support for health R&D, by performer and source of funds: 1979-91

Sector	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 (est.)	1991 (est.)
	Millions of current dollars												
Total	7,150	7,953	8,723	9,548	10,753	12,143	13,512	14,832	16,868	18,905	20,900	22,584	24,542
Source of funds													
Government	4,786	5,203	5,413	5,612	6,117	6,886	7,675	7,930	9,037	9,721	10,695	11,373	12,013
Federal	4,321	4,723	4,848	4,970	5,399	6,087	6,791	6,895	7,847	8,425	9,230	9,856	10,383
Nat'l Institutes of Health	2,953	3,182	3,333	3,433	3,789	4,257	4,828	5,005	5,852	6,292	6,778	7,141	7,472
State and local	465	480	564	642	718	799	884	1,034	1,191	1,295	1,465	1,517	1,630
Industry	2,093	2,459	2,998	3,593	4,205	4,765	5,352	6,188	7,103	8,432	9,404	10,368	11,619
Private nonprofit	271	292	312	343	431	491	486	715	728	753	801	843	910
Howard Hughes Med. Inst[1]	17	18	20	25	54	79	51	247	183	179	197	215	246
Performer													
Government	1,309	1,487	1,575	1,668	1,813	1,996	2,139	2,153	2,387	2,588	2,853	3,016	3,178
Federal	1,120	1,284	1,364	1,448	1,577	1,741	1,869	1,847	2,042	2,213	2,432	2,574	2,706
State and local	189	203	211	221	236	255	270	306	346	375	421	442	472
Industry[2]	1,932	2,249	2,659	3,161	3,668	4,216	4,660	5,293	6,015	6,927	7,850	8,595	9,578
Higher education[2]	2,818	2,998	3,204	3,362	3,769	4,268	4,823	5,281	6,011	6,519	7,178	7,663	8,168
Private nonprofit[2]	688	720	744	767	874	968	1,087	1,130	1,330	1,431	1,564	1,672	1,775
Foreign	403	499	542	591	630	696	803	975	1,138	1,441	1,456	1,639	1,844
Biomedical R&D price index[3]	0.768	0.840	0.921	1.000	1.060	1.121	1.178	1.227	1.294	1.359	1.429	1.512	1.603
	Millions of constant 1982 dollars												
Total	9,315	9,473	9,469	9,548	10,147	10,833	11,471	12,090	13,041	13,915	14,623	14,935	15,313
Source of funds													
Government	6,235	6,197	5,875	5,612	5,772	6,143	6,516	6,464	6,986	7,155	7,483	7,521	7,495
Federal	5,630	5,625	5,263	4,970	5,095	5,430	5,765	5,621	6,066	6,201	6,458	6,518	6,478
Nat'l Institutes of Health	3,847	3,790	3,618	3,433	3,576	3,798	4,099	4,080	4,524	4,631	4,742	4,722	4,662
State and local	605	572	612	642	678	713	750	843	921	953	1,025	1,003	1,017
Industry	2,727	2,928	3,254	3,593	3,968	4,251	4,544	5,044	5,491	6,206	6,579	6,856	7,250
Private nonprofit	354	347	339	343	407	438	412	583	563	554	560	557	568
Howard Hughes Med. Inst.	22	21	22	25	51	70	43	201	141	132	138	142	153
Performer													
Government	1,705	1,772	1,709	1,668	1,711	1,781	1,816	1,755	1,845	1,905	1,996	1,994	1,983
Federal	1,459	1,530	1,480	1,448	1,488	1,553	1,587	1,506	1,579	1,629	1,701	1,702	1,688
State and local	246	242	229	221	222	227	229	249	267	276	295	292	295
Industry[2]	2,517	2,679	2,886	3,161	3,461	3,761	3,956	4,314	4,650	5,099	5,492	5,684	5,976
Higher education[2]	3,671	3,571	3,478	3,362	3,557	3,808	4,095	4,305	4,647	4,798	5,022	5,067	5,096
Private nonprofit[2]	896	857	808	767	824	864	922	921	1,028	1,053	1,094	1,106	1,108
Foreign	525	594	588	591	595	621	682	795	880	1,061	1,019	1,084	1,151

[1] For Howard Hughes Medical Institute, figures are for the direct conduct of biomedical research and exclude support for scientific career development. Figures for 1985 include only 8 months of operations because of change in fiscal year.

[2] Includes expenditures for federally funded research and development centers administered by organizations in the respective sectors.

[3] The biomedical R&D price index used here differs from the GNP implicit price deflator detailed in appendix table 4-1.

SOURCE: National Institutes of Health, *NIH Data Book* (Bethesda, MD: NIH, annual series).

Appendix table 4-20.
Public and private R&D expenditures for health and agriculture: selected years, 1960-89

National support for health-related R&D

		Public funds		Private funds		Health R&D		Public funds		Private funds	
	Total	Federal	State[1]	Industry	Nonprofit	deflator[2]	Total	Federal	State	Industry	Nonprofit
	Millions of dollars						Millions of constant 1980 dollars				
1960	886	448	46	253	139	0.3454	2,565	1,297	133	732	402
1965	1,890	1,174	90	450	176	0.3901	4,845	3,009	231	1,154	451
1970	2,847	1,667	170	795	215	0.4948	5,754	3,369	344	1,607	435
1975	4,701	2,832	286	1,319	264	0.6779	6,935	4,178	422	1,946	389
1980	7,953	4,723	480	2,459	292	1.0000	7,953	4,723	480	2,459	292
1985	13,513	6,791	884	5,352	486	1.4029	9,632	4,840	630	3,815	346
1989	20,900	9,230	1,465	9,404	801	1.7022	12,278	5,422	861	5,525	471

National performance of food and agriculture R&D[3]

		Public	Industry		Agriculture R&D		Public	Industry	
	Total	research[4]	Input[5]	Food	deflator[6]	Total	research[4]	Input	Food
	Millions of dollars					Millions of constant 1980 dollars			
1960	435	217	126	92	0.3303	1,317	657	381	279
1965	669	346	192	131	0.4043	1,655	856	475	324
1970	997	505	286	206	0.5430	1,836	930	527	379
1975	1,475	749	453	273	0.7326	2,013	1,022	618	373
1980	2,632	1,186	938	508	1.0000	2,632	1,186	938	508
1985	4,029	1,664	1,370	995	1.4078	2,862	1,182	973	707
1989	4,836	2,089	1,625	1,122	1.5213	3,179	1,373	1,068	738

[1] Includes state and local government funds.

[2] Index is the National Institutes of Health biomedical research and development price index. Base year = 1980.

[3] Public sector performers, including state agricultural experiment stations (SAES) affiliated with land-grant universities, receive 95 percent of their funds from public sector sources. Private sector performers, including private research firms, receive more than 95 percent of their funds from private sector sources.

[4] Includes research conducted by the Department of Agriculture's (USDA's) Agricultural Research Service and Economic Research Service, and research conducted at all SAES using both Federal and non-Federal (primarily state government) funds.

[5] Includes R&D performed by agricultural input industries: agricultural chemicals, farm machinery, seeds, veterinary medicine, and agricultural biotechnology.

[6] Index for 1960-85 is an index specific to agriculture R&D developed by Pardey, Craig, and Hallaway. Index number for 1989 is based on the historical relationship between the Pardey index and the GNP implicit price deflator. Base year = 1980.

SOURCES: National Institutes of Health, *NIH Data Book* (Washington, DC: NIH, annual series); NIH unpublished tabulations; C.E. Pray and C. Neumeyer, "Trends and Composition of Private Food and Agricultural R&D Expenditure in the United States," P-02221-1-89 (New Brunswick, NJ: Rutgers College, 1989); personal communication with Dr. Pray; USDA, "Inventory of Agricultural Research: Current Research Information System" (Washington, DC: USDA, annual series); and P.G. Pardey, B. Craig, and M.L. Hallaway, "U.S. Agricultural Research Deflators: 1890-1985," *Research Policy* 18: 289-96.

See figure 4-11.

Science & Engineering Indicators – 1991

Appendix table 4-21.

Budgetary impact of the Federal research and experimentation (R&E) tax credit: FYs 1981-92

	Cost of R&E credit[1]		Total Federal R&D outlays (c)	Ratio of credit outlays to R&D (a)/(c)	Cost of R&E credit		Total Federal R&D outlays
	Outlay equivalent (a)	Revenue loss (b)			Outlay equivalent	Revenue loss	
	Millions of current dollars			Percent	Millions of constant 1982 dollars[2]		
1981	205	15	32,459	0.63	220	16	34,825
1982	640	415	34,391	1.86	640	415	34,391
1983	1,010	615	36,659	2.76	969	590	35,170
1984	3,360	1,380	39,691	8.47	3,106	1,276	36,686
1985	2,430	1,665	44,171	5.50	2,179	1,493	39,604
1986	2,295	680	50,609	4.53	2,004	594	44,196
1987	2,715	1,865	51,612	5.26	2,300	1,580	43,727
1988	1,240	900	54,739	2.27	1,020	740	45,009
1989	1,590	1,145	59,450	2.67	1,255	903	46,906
1990	1,625	1,115	63,158	2.57	1,233	846	47,911
1991	1,680	1,155	63,440	2.65	1,220	839	46,086
1992	1,220	835	68,065	1.79	851	583	47,503

NOTES: Tax expenditure estimates are prepared by the Treasury Department based on income tax law enacted as of December 31st of the year for which the expenditures are reported. Expenditures for the years 1990-92 are estimated based on the assumption that the tax structure existing December 31, 1990, is unchanged.

[1] "Outlay equivalent" estimates are comparable to taxable outlay figures reported in the budget. This allows a comparison of the resource cost of the tax credit with the cost of direct Federal R&D expenditure support. The "revenue loss" estimates are net of taxes.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Office of Management and Budget, *Budget of the United States Government* (Washington, DC: OMB, annual series).

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Appendix table 4-22.
Geographic distribution of U.S. R&D expenditures, by performer and source of funds: 1989
(page 1 of 2)

			Industry			Universities and colleges (U&C)[1]						U&C FFRDCs		
Geographic area	Total all sectors	Federal intra-mural	Total	Federal Gov't	Industry	Total	Federal Gov't	Non-Fed. gov't	Industry	U&C	Other	Total	Federal Gov't	Non-profits[2]
	Millions of current dollars													
TOTAL U.S.	139,842	14,651	101,599	31,366	70,233	14,701	8,804	1,201	963	2,669	1,064	4,729	4,692	3,876
New England	11,710	665	8,789	2,416	6,373	1,357	944	33	107	149	124	364	364	535
Connecticut	2,745	38	2,410	680	1,730	284	187	5	12	57	23	0	0	13
Maine	72	4	33	0	33	20	8	1	4	7	1	0	0	15
Massachusetts	7,949	401	5,825	1,691	4,134	868	622	19	79	59	90	364	364	491
New Hampshire[3]	202	22	95-140	D	95	62	42	3	3	9	5	0	0	0
Rhode Island	428	196	139	D	D	80	56	3	6	12	2	0	0	13
Vermont[3]	314	4 242	287	D	D	43	29	3	3	5	3	0	0	3
Middle Atlantic	22,918	793	19,084	3,988	15,096	2,376	1,454	147	179	364	232	389	388	276
New Jersey	7,229	430	6,381	601	5,780	283	118	45	17	83	20	113	112	22
New York	9,898	89	8,071	1,480	6,591	1,332	867	69	71	172	154	255	255	151
Pennsylvania	5,791	274	4,632	1,907	2,725	761	469	32	92	109	59	21	21	103
South Atlantic	17,779	6,538	8,100	2,598	5,502	2,720	1,673	262	178	499	109	32	31	389
Delaware[4]	8873	845	1,03	D	D	37	17	3	4	11	2	0	0	2
District of Columbia[5]	1,982	1,522	23-210	D	23	114	85	1	7	16	6	0	0	136
Florida	3,375	642	2,341	1,167	1,174	386	200	26	21	113	26	0	0	6
Georgia	1,302	158	719	D	D	417	205	40	35	125	12	0	0	8
Maryland	5,091	3,012	1,088	552	536	922	706	64	35	92	25	0	0	69
North Carolina	1,826	60	1,305	5	1,300	425	262	61	41	47	14	0	0	36
South Carolina	576	60	386	D	D	120	42	17	8	45	8	0	0	10
Virginia	2,536	1,018	1,126	687	439	259	139	49	22	34	14	13	12	120
West Virginia[4]	203	63	80-267	D	80	39	17	1	4	15	2	18	18	2
Southeast	3,132	864	1,640	653	987	581	304	78	40	118	41	8	8	39
Alabama	1,223	568	428	213	215	207	115	18	16	41	16	0	0	20
Kentucky	343	31	226	0	226	84	33	7	8	31	6	0	0	2
Mississippi	264	130	56	D	D	75	32	20	5	10	8	0	0	3
Tennessee	1,302	135	930	D	D	215	124	32	10	37	11	8	8	14
Southwest	7,589	571	5,580	1,886	3,694	1,345	602	184	80	321	158	0	0	93
Arkansas	121	25	51	D	D	44	14	12	4	10	4	0	0	1
Louisiana	384	36	168	D	D	179	66	43	8	47	15	0	0	1
Oklahoma	507	46	332	D	D	113	33	5	6	60	9	0	0	16
Texas	6,576	464	5,028	1,848	3,180	1,009	488	124	62	205	130	0	0	75
Great Lakes	23,347	1,288	19,308	1,267	18,041	2,072	1,178	195	136	415	148	528	521	151
Illinois	5,307	59	4,050	D	D	604	338	36	39	151	41	528	521	65
Indiana	2,120	75	1,815	D	D	227	136	19	18	44	10	0	0	3
Michigan	9,057	71	8,468	99	8,369	486	263	36	36	116	35	0	0	32
Ohio	5,465	1,056	3,946	681	3,265	417	242	49	26	62	38	0	0	46
Wisconsin	1,399	27	1,030	32	998	337	198	55	16	43	24	0	0	5

(continued)

Appendix table 4-22.

Geographic distribution of U.S. R&D expenditures, by performer and source of funds: 1989

(page 2 of 2)

Geographic area	Total all sectors	Federal intra-mural	Industry: Total	Industry: Federal Gov't	Industry: Industry	Universities and colleges (U&C)[1]: Total	U&C: Federal Gov't	U&C: Non-Fed. gov't	U&C: Industry	U&C: U&C	U&C: Other	U&C FFRDCs: Total	U&C FFRDCs: Federal Gov't	Non-profits[2]
	Millions of current dollars													
Plains	6,530	166	5,307	1,770	3,537	965	483	135	69	220	58	22	22	70
Iowa	616	20	363	D	D	209	103	25	15	61	6	22	22	2
Kansas	523	9	404	94	310	108	44	24	5	30	4	0	0	2
Minnesota	2,399	31	2,066	D	D	259	133	43	12	44	27	0	0	43
Missouri	2,710	58	2,380	D	D	255	140	15	25	60	16	0	0	17
Nebraska	182	22	64	D	D	94	37	23	9	21	4	0	0	2
North Dakota	79	20	27	0	27	28	19	1	3	4	1	0	0	4
South Dakota	23	6	4	0	4	12	6	5	0	1	0	0	0	0
Mountain	7,109	1,021	4,095	1,896	2,199	874	514	70	62	182	46	993	978	126
Arizona	1,293	118	917	220	697	224	105	8	13	86	12	28	28	7
Colorado	1,649	117	1,162	251	911	226	167	11	14	18	17	63	61	80
Idaho[5]	614	19	161-561	D	161	33	13	8	4	8	0	0	0	1
Montana[4]	59	21	5-405	D	5	32	12	8	3	10	0	0	0	1
Nevada	141	77	29	D	D	34	18	2	4	9	1	0	0	1
New Mexico	2,680	594	1,034	D	D	136	77	15	16	18	11	902	889	13
Utah	620	66	387	D	D	165	109	17	6	28	5	0	0	2
Wyoming[4]	53	9	0-400	D	D	23	14	2	2	6	0	0	0	21
Pacific	34,925	2,718	26,764	14,193	12,571	2,411	1,653	97	113	400	148	2,385	2,373	647
Alaska	118	51	9	D	D	57	27	2	3	22	3	0	0	1
California	30,881	2,478	23,675	12,857	10,818	1,846	1,281	43	83	322	116	2,385	2,373	497
Hawaii	123	36	9	2	7	71	41	25	1	4	1	0	0	7
Oregon	579	42	355	30	325	161	99	21	5	17	20	0	0	21
Washington	3,225	111	2,716	D	D	277	205	6	21	36	8	0	0	121
Other/unknown	4,803	27	2,932	699	2,233	286	—	—	—	—	—	8	8	1,550

D = withheld to avoid disclosing operations of individual companies; — = unknown

[1] Funds distributed by state for universities and colleges are for doctorate-granting institutions only. R&D performed at non-doctorate-granting institutions is included in "other/unknown."

[2] For the nonprofit sector, funds distributed by state include only Federal obligations to organizations in this sector. Estimated non-Federal support to the nonprofit sector is included in "other/unknown."

[3] For the industry sector, reported data fall within the range specified, but have been withheld by the Census Bureau to avoid disclosing individual company operations. Amount for state total is R&D performance of Federal Government, universities and colleges, academic federally funded research and development centers (FFRDCs), and nonprofit sector, plus the midpoint of the industry R&D performance range.

[4] For the industry sector, reported data fall within the range specified, but have been withheld by the Census Bureau to avoid disclosing individual company operations. Amount for state total is R&D performance of Federal Government, universities and colleges, academic FFRDCs, and nonprofit sector, plus the low end of the industry R&D performance range. Use of low end of range based on reported National Science Foundation (NSF) industry data for 1985 and 1987, and Federal obligation data for 1989; this implicitly assumes that there were no major shifts in industry R&D performance between 1987 and 1989.

[5] For the industry sector, reported data fall within the range specified, but have been withheld by the Census Bureau to avoid disclosing individual company operations. Amount for state total is R&D performance of Federal Government, universities and colleges, academic FFRDCs, and nonprofit sector, plus the high end of the industry R&D performance range. Use of high end of range based on reported NSF industry data for 1985 and 1987, and Federal obligation data for 1989; this implicitly assumes that there were no major shifts in industry R&D performance between 1987 and 1989.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figure 4-12 and text tables 4-5 and 4-6.

Appendix table 4-23.
States leading in R&D performance by sector and R&D as a percentage of gross state product (GSP): 1989

Total R&D ($ millions)	All sectors[1]	Industry	Universities & colleges[2]	Federal Government	R&D intensity of state economy		
	Largest 25 performers (ranked by size of R&D)					R&D/GSP	GSP[3] ($ billion)
30,881	1 California	California	California	Maryland	New Mexico	9.8%	27.2
9,898	2 New York	Michigan	New York	California	Delaware	5.7%	15.7
9,057	3 Michigan	New York	Texas	Ohio	Massachusetts	5.5%	145.8
7,949	4 Massachusetts	New Jersey	Maryland	Virginia	Maryland	5.1%	99.0
7,229	5 New Jersey	Massachusetts	Massachusetts	Florida	Michigan	5.0%	181.4
6,576	6 Texas	Texas	Pennsylvania	New Mexico	California	4.5%	680.7
5,791	7 Pennsylvania	Pennsylvania	Illinois	Alabama	Idaho	3.8%	16.2
5,465	8 Ohio	Illinois	Michigan	Texas	New Jersey	3.7%	197.5
5,307	9 Illinois	Ohio	North Carolina	New Jersey	Washington	3.3%	99.2
5,091	10 Maryland	Washington	Georgia	Massachusetts	Connecticut	3.0%	90.4
3,375	11 Florida	Connecticut	Ohio	Pennsylvania	Vermont	2.8%	11.2
3,225	12 Washington	Missouri	Florida	Rhode Island	Missouri	2.7%	99.9
2,745	13 Connecticut	Florida	Wisconsin	Georgia	Ohio	2.6%	211.2
2,710	14 Missouri	Minnesota	Connecticut	Tennessee	Minnesota	2.5%	94.2
2,680	15 New Mexico	Indiana	New Jersey	Mississippi	Pennsylvania	2.5%	227.6
2,536	16 Virginia	North Carolina	Washington	Arizona	Colorado	2.4%	67.9
2,399	17 Minnesota	Colorado	Virginia	Colorado	Rhode Island	2.2%	19.2
2,120	18 Indiana	Virginia	Minnesota	Washington	New York	2.2%	448.2
1,826	19 North Carolina	Maryland	Missouri	New York	Utah	2.2%	28.7
1,649	20 Colorado	New Mexico	Indiana	Nevada	Illinois	2.1%	257.7
1,399	21 Wisconsin	Wisconsin	Colorado	Indiana	Indiana	2.0%	104.6
1,302	22 Georgia	Tennessee	Arizona	Michigan	Arizona	2.0%	64.7
1,302	23 Tennessee	Arizona	Tennessee	Utah	Texas	1.9%	346.8
1,293	24 Arizona	Delaware	Iowa	West Virginia	Virginia	1.9%	133.9
1,223	25 Alabama	Georgia	Alabama	North Carolina	Alabama	1.8%	66.7
Less than $1 billion	Smallest 25 performers (listed alphabetically)					1.5% or less	
..	Alaska	Alabama	Alaska	Alaska	Alaska	..	21.3
..	Arkansas	Alaska	Arkansas	Arkansas	Arkansas	..	37.5
..	Delaware	Arkansas	Delaware	Connecticut	Florida	..	230.4
..	Hawaii	Hawaii	Hawaii	Delaware	Georgia	..	127.4
..	Idaho	Idaho	Idaho	Hawaii	Hawaii	..	25.8
..	Iowa	Iowa	Kansas	Idaho	Iowa	..	54.6
..	Kansas	Kansas	Kentucky	Illinois	Kansas	..	49.8
..	Kentucky	Kentucky	Louisiana	Iowa	Kentucky	..	65.1
..	Louisiana	Louisiana	Maine	Kansas	Louisiana	..	81.6
..	Maine	Maine	Mississippi	Kentucky	Maine	..	23.0
..	Mississippi	Mississippi	Montana	Louisiana	Mississippi	..	38.2
..	Montana	Montana	Nebraska	Maine	Montana	..	13.9
..	Nebraska	Nebraska	Nevada	Minnesota	Nebraska	..	31.7
..	Nevada	Nevada	New Hampshire	Missouri	Nevada	..	27.4
..	New Hampshire	New Hampshire	New Mexico	Montana	New Hampshire	..	23.8
..	North Dakota	North Dakota	North Dakota	Nebraska	North Carolina	..	128.0
..	Oklahoma	Oklahoma	Oklahoma	New Hampshire	North Dakota	..	12.1
..	Oregon	Oregon	Oregon	North Dakota	Oklahoma	..	54.9
..	Rhode Island	Rhode Island	Rhode Island	Oklahoma	Oregon	..	52.6
..	South Carolina	South Carolina	South Carolina	Oregon	South Carolina	..	56.8
..	South Dakota	South Dakota	South Dakota	South Carolina	South Dakota	..	11.8
..	Utah	Utah	Utah	South Dakota	Tennessee	..	91.0
..	Vermont	Vermont	Vermont	Vermont	West Virginia	..	26.8
..	West Virginia	West Virginia	West Virginia	Wisconsin	Wisconsin	..	94.2
..	Wyoming	Wyoming	Wyoming	Wyoming	Wyoming	..	11.6

[1] Includes in-state R&D performance of industry, universities, associated federally funded research and development centers (FFRDCs), and Federal agencies and the federally funded R&D performance of nonprofit institutions.

[2] Excludes R&D activities of FFRDCs located within these states.

[3] Gross state product data available from the Bureau of Economic Analysis (BEA) through 1986. GSP data for 1989 estimated here based on changes in employee compensation and proprietors' income between 1986 and 1989, as reported by BEA.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See text table 4-5.

Appendix table 4-24.
Summary of state programs related to science and technology (S&T) based economic development: selected programs
(page 1 of 2)

	Year formed[1]	Major state administrative agencies, commissions, and boards concerned with S&T-based economic development initiatives[2]	University focus		Industry focus	
			Grants	Centers	R&D tax incentives	Startup support
Alabama	1987	Alabama Science, Technology, & Energy Division	U	—	—	—
Alaska	1988	Alaska Science and Technology Foundation	I	—	—	—
Arizona	1990	Governor's Advisory Board on Science & High Technology	—	C	—	—
Arkansas	1983	Arkansas Science & Technology Authority	U	C	Credit	S
California	1989	California Office of Competitive Technology	UI	—	Other	—
Colorado	1986	Colorado Advanced Technology Institute	UI	C	—	—
Connecticut	1972	Connecticut Innovations Incorporated	UI	—	—	SV
Delaware	1986	Governor's High Technology Task Force	UI	—	Credit	—
Florida	1983	Florida High Technology and Industry Council	U	—	—	S
Georgia	1980	Advanced Technology Development Center	—	C	—	—
Hawaii	1983	High Technology Development Corporation	—	—	—	SV
Idaho	1988	Division of Science & Technology	U	—	—	—
Illinois	1981	Office of Technology Advancement and Development	UI	—	—	SV
Indiana	1982	Business Modernization and Technology Corporation	I	C	Credit	SV
Iowa	1983	Iowa High Technology Council	UI	C	Credit	SV
Kansas	1987	Kansas Technology Enterprise Corporation	UI	C	Credit	SV
Kentucky	1987	Office of Business and Technology	I	C	—	V
Louisiana	1988	Louisiana Partnership for Technology & Innovation	—	—	—	SV
Maine	1984	Maine Science and Technology Commission	U	C	Exemption	—
Maryland	1988	Office of Technology Development	I	—	Exemption	—
Massachusetts	1985	Executive Office of Economic Affairs	I	—	Exemption	V
Michigan	1985	Michigan Strategic Fund	UI	C	—	SV
Minnesota	1983	Minnesota Technology, Inc	—	C	Credit	V
Mississippi	1985	Institute of Technology Development	—	C	Credit	—
Missouri	1983	Missouri Corporation for Science & Technology	—	C	—	S
Montana	1985	Montana Science and Technology Alliance	I	C	—	SV
Nebraska	1986	Nebraska Research and Development Authority	I	C	—	SV
Nevada	1990	Industry, Science, Engineering & Technology Task Force	—	—	—	—
New Hampshire	1991	Office of Business and Industrial Development	—	—	—	—
New Jersey	1985	New Jersey Commission on Science and Technology	U	C	Exemption	—
New Mexico	1981	Economic Development Department	UI	C	—	S
New York	1982	New York Science and Technology Foundation	I	C	—	SV
North Carolina	1963	North Carolina Board of Science and Technology	I	C	Credit	SV
North Dakota	1991	Science and Technology Corporation	U	—	—	SV
Ohio	1983	Thomas Alva Edison Program	UI	C	—	SV
Oklahoma	1987	OK Center for the Advancement of Science & Technology	I	C	—	SV
Oregon	1985	Oregon Resource and Technology Development Corporation	I	—	—	SV
Pennsylvania	1982	Ben Franklin Partnership Program	UI	—	Exemption	SV
Rhode Island	1985	Rhode Island Partnership for Science and Technology	U	—	Other	—
South Carolina	1983	South Carolina Research Authority	—	—	—	S

(continued)

Appendix table 4-24.

Summary of state programs related to science and technology (S&T) based economic development: selected programs

(page 2 of 2)

	Year formed[1]	Major state administrative agencies, commissions, and boards concerned with S&T-based economic development initiatives[2]	University focus		Industry focus	
			Grants	Centers	R&D tax incentives	Startup support
South Dakota	1988	The Future Fund	UI	—	—	S
Tennessee	1982	Tennessee Technology Foundation	—	C	—	V
Texas	1987	Office of Advanced Technology	—	—	—	V
Utah	1985	Centers of Excellence Program	I	C	—	SV
Vermont	1988	Governor's Advisory Council on Technology	U	—	Exemption	—
Virginia	1984	Center for Innovative Technology	UI	C	Exemption	—
Washington	1990	Office of Science & Technology	—	C	Credit	V
West Virginia	1977	Office of Community & Industrial Development	—	—	Credit	V
Wisconsin	1990	Bureau of Research and Technology	U	C	Credit	—
Wyoming	1989	Science, Technology and Energy Authority	UI	—	—	—

NOTES: University focus to foster research and technology aimed at local economic development:
U = States sponsoring university research grants (partnerships with industry)
I = States funding research grants to industry, generally with active university participation
C = States with university research centers, which generally draw on the strengths of major industries in the state

R&D tax incentives:
Exemption = R&D materials and/or equipment are exempt from sales/use taxes
Credit = State tax credit on qualified R&D expenses conducted in-state
Other = California allows R&D expenses to be deducted from state taxes and Rhode Island provides accelerated tax depreciation for R&D facilities

Startup support (includes programs for which the state provides ongoing support/oversight or one-time capitalization):
S = States with seed capital programs to assist companies yet to develop a marketable product
V = States with venture capital programs to assist developing companies with established business plans and commercially feasible projects

[1] Formation year can be that of a predecessor organization so long as the S&T activities of the successor organization(s) remained substantially unchanged. Date can be considered as year of state's initial involvement in S&T development.

[2] In some states there is more than one major agency responsible for S&T development.

SOURCES: Technology Administration, U.S. Department of Commerce, Clearinghouse for State and Local Initiatives in Productivity, Technology, and Innovation, unpublished tabulations (data as of August 1991); supplemental information from Paul Phelps, ADD, Inc., Alexandria, VA, personal communication.

See figure 4-13.

Appendix table 4-25.
State agency expenditures from state funds for R&D and R&D plant: 1977 and 1988

	R&D expenditures		R&D plant		R&D expenditures		R&D plant	
	1977	1988	1977	1988	1977	1988	1977	1988
	Thousands of current dollars				Thousands of constant 1982 dollars[1]			
TOTAL, ALL STATES	197,561	769,264	8,149	198,681	293,640	634,026	12,112	163,753
Alabama	385	1,047	33	0	572	863	49	0
Alaska	3,612	6,927	175	256	5,369	5,709	260	211
Arizona	429	670	27	42	638	552	40	35
Arkansas	211	1,027	41	0	314	846	61	0
California	23,659	53,305	81	1,215	35,165	43,934	120	1,001
Colorado	1,609	1,416	5	0	2,391	1,167	7	0
Connecticut	2,300	8,358	321	1,220	3,419	6,889	477	1,006
Delaware	202	2,511	22	0	300	2,070	33	0
Florida	7,374	13,736	1,254	365	10,960	11,321	1,864	301
Georgia	1,251	8,992	0	0	1,859	7,411	0	0
Hawaii	2,298	2,994	497	6,160	3,416	2,468	739	5,077
Idaho	595	961	0	0	884	792	0	0
Illinois	10,563	42,705	432	1,533	15,700	35,197	642	1,263
Indiana[2]	2,658	8,050	12	0	3,951	6,635	18	0
Iowa	1,179	7,800	63	0	1,752	6,429	94	0
Kansas	987	7,621	0	56	1,467	6,281	0	46
Kentucky	5,418	6,733	1,511	3,405	8,053	5,549	2,246	2,806
Louisiana	4,450	2,799	478	267	6,614	2,307	710	220
Maine	666	2,556	4	404	990	2,107	6	333
Maryland	7,606	172,148	97	3,684	11,305	141,884	144	3,036
Massachusetts	1,839	6,027	236	0	2,733	4,967	351	0
Michigan	4,797	15,192	114	51	7,130	12,521	169	42
Minnesota	2,987	6,160	48	488	4,440	5,077	71	402
Mississippi[2]	909	2,428	0	0	1,351	2,001	0	0
Missouri	634	955	107	23	942	787	159	19
Montana	1,783	3,166	4	394	2,650	2,609	6	325
Nebraska	252	1,483	14	0	375	1,222	21	0
Nevada[2]	199	1,806	1	0	296	1,489	1	0
New Hampshire	270	0	21	0	401	0	31	0
New Jersey	2,060	21,006	60	23,020	3,062	17,313	89	18,973
New Mexico	2,380	34,110	255	2,790	3,537	28,113	379	2,300
New York	64,298	194,336	441	137,570	95,568	160,171	655	113,385
North Carolina	5,076	10,782	65	1,474	7,545	8,887	97	1,215
North Dakota	1,077	906	99	4	1,601	747	147	3
Ohio	5,302	29,361	11	606	7,880	24,199	16	499
Oklahoma	643	604	12	317	956	498	18	261
Oregon	1,750	1,992	90	0	2,601	1,642	134	0
Pennsylvania	5,712	35,592	4	3,084	8,490	29,335	6	2,542
Rhode Island	491	1,024	100	10	730	844	149	8
South Carolina	2,189	4,616	680	2,262	3,254	3,805	1,011	1,864
South Dakota	872	1,471	0	168	1,296	1,212	0	138
Tennessee	518	2,313	1	0	770	1,906	1	0
Texas	4,914	10,952	70	7	7,304	9,027	104	6
Utah	803	968	255	50	1,194	798	379	41
Vermont	100	300	0	0	149	247	0	0
Virginia	2,959	10,475	346	256	4,398	8,633	514	211
Washington	2,637	12,480	23	7,450	3,919	10,286	34	6,140
West Virginia	227	324	0	0	337	267	0	0
Wisconsin	2,251	5,783	31	50	3,346	4,766	46	41
Wyoming	180	296	8	0	268	244	12	0

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

[2] Expenditures only for the state's lead science and technology or research and development agency.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Research and Development in State and Local Governments, Fiscal Year 1977*, NSF 79-327 (Washington, DC: NSF, 1979); and SRS, *Research and Development Expenditures of State Government Agencies: Fiscal Years 1987 and 1988*, NSF 90-309 (Washington, DC: NSF, 1990).

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Appendix table 4-26.
International R&D expenditures and R&D as a percentage of GNP: 1961-89

	R&D expenditures[1]							R&D expenditures as a percentage of GNP						
	United States	Japan	West Germany	France[2]	United Kingdom	Italy	Sweden	United States	Japan	West Germany	France[2]	United Kingdom	Italy	Sweden
	Billions of constant 1982 dollars							Percent						
1961	45.8	3.9	NA	3.2	8.1	NA	NA	2.7	1.4	NA	1.4	2.5	NA	NA
1962	48.2	4.4	4.2	3.6	NA	NA	NA	2.7	1.5	1.2	1.5	NA	NA	NA
1963	52.6	4.9	4.9	4.0	NA	1.5	NA	2.8	1.5	1.4	1.6	NA	0.6	NA
1964	57.2	5.5	5.8	5.0	8.4	NA	0.7	2.9	1.5	1.6	1.8	2.3	NA	1.2
1965	59.4	6.1	6.7	5.8	NA	1.6	NA	2.8	1.6	1.7	2.0	NA	0.7	NA
1966	62.6	6.6	7.3	6.3	8.8	NA	NA	2.8	1.5	1.8	2.1	2.3	NA	NA
1967	64.4	7.6	7.9	6.8	8.9	2.0	0.8	2.8	1.6	2.0	2.2	2.3	0.7	1.3
1968	65.5	9.0	8.4	7.0	9.1	2.3	NA	2.8	1.7	2.0	2.1	2.2	0.8	NA
1969	64.7	10.5	8.3	7.1	9.4	2.6	0.8	2.7	1.7	1.8	2.0	2.3	0.8	1.3
1970	62.4	12.6	10.1	7.5	NA	3.0	NA	2.6	1.9	2.1	1.9	NA	0.9	NA
1971	60.4	13.5	11.0	7.8	NA	3.1	1.1	2.4	1.9	2.2	1.9	NA	0.9	1.5
1972	61.4	14.9	11.5	8.0	9.3	3.2	NA	2.4	1.9	2.2	1.9	2.1	0.9	NA
1973	62.4	16.3	11.4	8.0	NA	3.3	1.2	2.3	2.0	2.1	1.8	NA	0.8	1.6
1974	61.5	16.6	11.6	8.3	NA	3.2	NA	2.2	2.0	2.1	1.8	NA	0.8	NA
1975	59.9	16.8	12.0	8.3	10.1	3.5	1.4	2.2	2.0	2.2	1.8	2.1	0.9	1.7
1976	62.1	17.5	12.2	8.5	NA	3.4	NA	2.2	2.0	2.1	1.8	NA	0.9	NA
1977	63.7	18.2	12.5	8.7	NA	3.6	1.5	2.2	2.0	2.1	1.8	NA	0.9	1.8
1978	66.8	19.3	13.5	9.0	11.1	3.5	NA	2.1	2.0	2.2	1.8	2.2	0.8	NA
1979	70.1	21.2	15.2	9.6	NA	3.7	1.6	2.2	2.1	2.4	1.8	NA	0.8	1.9
1980	73.3	23.4	15.5	9.9	NA	3.9	NA	2.3	2.2	2.4	1.8	NA	0.9	NA
1981	76.6	25.8	16.1	10.9	12.2	4.6	2.0	2.4	2.3	2.5	2.0	2.4	1.0	2.4
1982	80.0	27.7	16.5	11.7	NA	4.8	NA	2.5	2.4	2.6	2.1	NA	1.1	NA
1983	85.8	30.1	16.0	12.0	11.9	5.1	2.3	2.6	2.6	2.5	2.1	2.2	1.1	2.6
1984	93.8	32.6	17.0	12.7	NA	5.5	NA	2.7	2.6	2.6	2.2	NA	1.0	NA
1985	102.5	36.1	18.8	13.1	12.8	6.3	2.8	2.8	2.8	2.8	2.3	2.3	1.1	3.0
1986	104.9	36.5	19.3	13.3	13.5	6.5	NA	2.8	2.8	2.8	2.2	2.4	1.1	NA
1987	106.6	39.1	20.2	13.8	13.6	7.1	3.0	2.8	2.8	2.9	2.3	2.3	1.2	3.0
1988	110.2	42.0	20.6	14.4	13.5	8.2	NA	2.7	2.9	2.9	2.3	2.2	1.3	NA
1989	111.1	45.9	21.9	15.0	13.2	8.2	2.9	2.7	3.0	2.9	2.3	2.0	1.3	2.8

NA = not available

[1] Conversions of foreign currencies to U.S. dollars are calculated with Organisation for Economic Cooperation and Development purchasing power parity exchange rates. Constant 1982 dollars are based on U.S. Department of Commerce GNP implicit price deflators.

[2] French data are based on gross domestic product (GDP); consequently, percentages may be slightly overstated compared to GNP.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update* (Washington, DC: NSF, ongoing series).

See figures O-1 and O-2 in Overview.

Appendix table 4-27.
International nondefense R&D expenditures and nondefense R&D as a percentage of GNP: 1971-89

	Nondefense R&D expenditures[1]							Nondefense R&D expenditures as a percentage of GNP						
	United States	Japan	West Germany	France[2]	United Kingdom	Italy	Sweden	United States	Japan	West Germany	France[2]	United Kingdom	Italy	Sweden
	Billions of constant 1982 dollars							Percent						
1971	41.8	13.3	10.2	6.0	NA	3.1	NA	1.7	1.9	2.0	1.5	NA	0.9	NA
1972	42.1	14.8	10.8	6.3	6.9	3.2	NA	1.6	1.9	2.1	1.5	1.5	0.9	NA
1973	43.8	16.2	10.6	6.2	NA	3.2	NA	1.6	2.0	1.9	1.4	NA	0.8	NA
1974	44.2	16.5	10.9	6.6	NA	3.1	NA	1.6	2.0	2.0	1.4	NA	0.8	NA
1975	43.1	16.7	10.9	6.7	7.2	3.5	1.2	1.6	2.0	2.1	1.5	1.5	0.9	1.4
1976	45.3	17.4	11.5	6.9	NA	3.4	NA	1.6	2.0	2.0	1.4	NA	0.8	NA
1977	46.0	18.1	11.8	7.1	NA	3.5	1.2	1.6	2.0	2.0	1.4	NA	0.9	1.5
1978	48.8	19.1	12.7	7.2	8.0	3.4	NA	1.6	2.0	2.1	1.4	1.6	0.8	NA
1979	52.4	21.1	14.4	7.5	NA	3.7	1.4	1.6	2.1	2.3	1.4	NA	0.8	1.7
1980	55.6	23.3	14.7	7.7	NA	3.9	NA	1.7	2.2	2.3	1.4	NA	0.8	NA
1981	56.9	25.7	15.4	8.2	8.7	4.4	1.9	1.8	2.3	2.4	1.5	1.7	1.0	2.2
1982	57.9	27.5	15.8	9.1	NA	4.6	NA	1.8	2.4	2.5	1.6	NA	1.0	NA
1983	64.8	29.9	15.3	9.4	8.5	4.9	2.1	1.9	2.5	2.4	1.7	1.6	1.1	2.4
1984	66.7	32.4	16.2	9.9	NA	NA	NA	1.9	2.6	2.5	1.7	NA	NA	NA
1985	72.2	35.9	17.9	10.5	9.1	6.0	2.5	2.0	2.8	2.7	1.8	1.6	1.1	2.6
1986	72.5	36.2	18.3	10.6	10.1	6.2	NA	1.9	2.8	2.7	1.8	1.7	1.1	NA
1987	73.4	38.8	19.2	10.8	10.7	6.7	2.7	1.9	2.8	2.8	1.8	1.8	1.2	2.7
1988	77.1	41.7	19.7	11.2	10.9	7.7	NA	1.9	2.9	2.7	1.8	1.7	1.3	NA
1989	79.0	45.5	20.9	11.8	10.4	7.7	2.6	1.9	3.0	2.8	1.8	1.6	1.2	2.5

NA = not available

[1] Nondefense expenditures are estimated here as total R&D expenditures—generally as reported by the R&D performers (see appendix table 4-26)—minus goverment R&D funds for defense purposes (see appendix table 4-30)—generally taken from national budget documents; that is, as reported by the R&D funders. Conversions of foreign currencies to U.S. dollars are calculated with Organisation for Economic Cooperation and Development purchasing power parity exchange rates. Constant 1982 dollars are based on U.S. Department of Commerce GNP implicit price deflator.

[2] French data are based on gross domestic product (GDP); consequently, percentages may be slightly overstated compared to GNP.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update* (Washington, DC: NSF, ongoing series).

See figure 4-15 and figures O-2 and O-3 in Overview.

Appendix table 4-28.

International comparison of R&D expenditures, by source of funds and sector of performance for selected countries: 1975 and 1989

	United States	Japan	West Germany	France	United Kingdom
Source of funds					
	Percent				
1975					
Total	100	100	100	100	100
Government	51	29	47	54	52
Industry	45	55	50	39	41
Higher education	2	15	0	1	1
Other[1]	2	1	2	6	7
Billions of constant 1982 dollars	$59.4	$16.7	$11.9	$8.1	$10.1
1989[2]					
Total	100	100	100	100	100
Government	45	19	33	49	37
Industry	51	72	65	43	51
Higher education	3	8	0	0	1
Other[1]	1	1	2	7	11
Billions of constant 1982 dollars	$111.1	$45.9	$21.9	$15.0	$13.2
Performing sector					
	Percent				
1975					
Total	100	100	100	100	100
Government	15	12	17	23	26
Industry	69	57	63	60	62
Higher education	13	28	20	16	8
Other[1]	4	3	*	1	3
Billions of constant 1982 dollars	$59.4	$16.7	$11.9	$8.1	$10.1
1989[2]					
Total	100	100	100	100	100
Government	11	8	13	24	15
Industry	72	70	72	60	67
Higher education	14	18	14	15	14
Other[1]	3	4	*	1	4
Billions of constant 1982 dollars	$111.1	$45.9	$21.9	$15.0	$13.2

* = less than 0.5 percent

NOTE: Percentages may not sum to 100 because of rounding.

[1] Private nonprofit institutions.

[2] French data for 1989 are NSF estimates; United Kingdom data are for 1988.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update* (Washington, DC: NSF, ongoing series).

See figure 4-14.

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Appendix table 4-29.

Basic research expenditures as a percentage of total R&D, by country: 1975-88

	United States	Japan	West Germany	France	United Kingdom	Italy	Sweden
	Percent						
1975	13	12	26	NA	14	20	NA
1976	13	15	25	NA	13	20	NA
1977	13	15	25	21	13	20	18
1978	14	16	22	NA	13	19	NA
1979	14	15	21	21	13	16	18
1980	13	14	21	21	13	15	NA
1981	13	13	22	21	13	15	23
1982	13	13	21	21	NA	15	NA
1983	13	13	21	21	NA	16	NA
1984	13	13	NA	20	NA	16	NA
1985	12	12	18	20	NA	16	20
1986	14	13	NA	20	NA	17	NA
1987	14	13	19	20	NA	NA	23
1988	14	13	NA	23	NA	NA	NA

NA = not available

NOTES: Data for basic research are somewhat less reliable than those for total R&D expenditures. Each percentage generally relates to the total current R&D expenditures; for countries other than the United States, this may include some general university funds. Data for France and the United Kingdom are estimated for certain years.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update* (Washington, DC: NSF, ongoing series).

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Appendix table 4-30.

Distribution of government R&D budget appropriations, by socioeconomic objective: 1984 and 1989

	United States		Japan		West Germany		France		United Kingdom	
Objective	1984	1989	1984	1989	1984	1989	1984	1989	1984	1989
	Percent									
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry, and fishing	2.2	1.9	10.9	3.7	2.4	2.1	4.7	4.1	5.0	4.5
Industrial development	0.2	0.2	6.1	4.6	11.6	12.8	11.7	13.3	8.5	8.5
Energy	5.8	3.9	14.0	22.2	15.0	6.4	7.9	3.5	5.3	3.3
Infrastructure	2.5	1.8	2.5	1.7	2.2	2.0	3.5	0.9	4.8	1.5
Transportation & telecommunications	2.4	1.7	1.4	1.4	1.1	0.5	2.2	NA	0.5	0.3
Urban and rural planning	0.1	0.1	1.1	0.3	1.1	1.5	1.3	NA	1.0	1.2
Environmental protection	0.5	0.5	1.4	0.4	2.8	3.4	0.5	0.7	1.2	1.3
Health	11.3	12.9	2.5	2.7	3.2	3.5	3.8	3.3	3.5	5.1
Social development and services	1.0	1.1	0.7	1.0	2.4	2.5	1.4	0.5	0.7	2.2
Earth and atmosphere	1.2	1.0	1.1	1.0	2.2	2.2	2.0	1.6	1.7	2.4
Advancement of knowledge	3.8	3.8	53.5	51.1	44.4	46.7	26.5	27.1	19.6	22.4
Advancement of research	3.8	3.8	1.7	7.8	11.4	13.9	16.2	15.5	5.1	4.8
General university funds	—	—	51.8	43.3	33.0	32.8	10.3	11.6	14.6	17.6
Civil space	5.2	7.3	4.4	6.3	3.9	5.7	5.8	7.7	2.2	3.1
Defense	66.2	65.5	2.8	5.1	9.8	12.8	31.3	37.0	49.4	45.5
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.4	1.8	0.3

NA = not separately available but included in subtotal

— = the United States does not have an equivalent to Europe's and Japan's general university funds

NOTES: Percentages may not sum to 100 because of rounding. U.S. data are based on budget authority. Because of general university funds and slight differences in accounting practices, the distribution of government budgets among socioeconomic objectives may not completely reflect the actual distribution of government-funded research in particular fields. Japanese data are based on science and technology budget data, which include items other than R&D. Such items are a small proportion of the budget, and therefore the data may still be used as an approximate indicator of relative government emphasis on R&D by objective.

SOURCE: Science Resources Studies Division, National Science Foundation, *International Science and Technology Data Update* (Washington, DC: NSF, ongoing series).

See text table 4-7.

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Appendix table 4-31.

Company-financed R&D performed outside the United States by U.S. companies and their foreign subsidiaries, by industry: 1974-89

Industry	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Millions of current U.S. dollars															
TOTAL	1,300	1,454	1,659	1,877	2,209	2,754	3,165	3,393	3,094	3,269	3,633	3,650	4,624	5,226	6,295	6,519
Food, kindred, and tobacco products[1]	27	23	29	32	43	51	54	62	64	63	70	75	69	37	27	34
Chemicals and allied products	208	269	312	332	395	500	603	715	682	729	786	843	1,071	1,243	1,501	1,287
Industrial and other chemicals	82	85	108	133	151	199	246	287	319	368	385	444	579	625	781	473
Drugs and medicines	126	184	204	199	244	301	357	428	363	361	401	399	492	618	720	814
Petroleum refining and extraction	*	*	*	*	*	*	141	194	133	103	101	47	40	47	58	46
Stone, clay, and glass products	7	7	*	*	*	NA	21	18	10	19	60	D	D	D	D	D
Primary metals	3	9	12	9	9	11	11	9	9	10	9	D	D	18	24	23
Fabricated metal products	*	*	22	24	29	NA	NA	30	25	23	21	21	26	40	D	D
Machinery	258	331	352	411	460	534	599	612	494	577	740	689	951	1,233	1,364	1,455
Electrical equipment	238	245	278	300	352	445	451	475	467	482	537	591	S	432	669	615
Radio and TV receiving equipment	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	D	D	0	D	D
Communication equipment	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	D	D	D	188	339	278
Electronic components	4	7	9	13	17	25	29	40	38	NA	92	117	150	204	278	245
Other electrical equipment	NA	NA	6	5	9	11	11	39	43	38	30	24	25	39	D	D
Transportation equipment	406	412	464	558	640	874	1,020	884	843	880	907	1,025	D	D	1,801	2,101
Motor vehicles & other transportation equipment	364	373	423	514	NA	NA	NA	NA	NA	NA	D	D	D	D	1,469	1,491
Aircraft and missiles	42	39	41	44	NA	NA	NA	NA	NA	NA	D	D	182	237	332	610
Professional and scientific instruments	39	49	69	81	121	156	186	230	237	NA	263	169	212	317	393	441
Other manufacturing industries	111	105	137	144	181	213	139	156	123	92	131	125	141	138	145	166
Nonmanufacturing industries	3	4	4	9	12	5	7	8	7	10	8	18	27	64	95	89
	Millions of constant 1982 U.S. dollars[2]															
TOTAL	2,409	2,452	2,630	2,790	3,059	3,505	3,692	3,611	3,094	3,148	3,372	3,290	4,063	4,450	5,188	5,161

D = withheld to avoid disclosing operations of individual companies
S = withheld because of imputation of more than 50 percent
* = included in the other manufacturing industries group
NA = not separately available, but included in totals

[1] Until 1984, the tobacco products category, Standard Industrial Classification code 21, was included in the other manufacturing industries group.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry* (Washington, DC: NSF, ongoing series); and unpublished tabulations.

See figure 4-16.

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Appendix table 4-32.
Foreign R&D expenditures in the United States, by industry and country: 1977-88

Industry and country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Millions of current U.S. dollars											
TOTAL	933	1,230	1,584	1,946	3,110	3,744	4,164	4,738	5,240	5,804	6,521	7,382
Expenditures by industry												
Manufacturing	851	1,099	1,450	D	2,898	3,388	3,863	4,424	4,866	5,391	5,884	6,747
Petroleum	108	158	149	D	253	255	310	366	388	380	311	345
Food and kindred products	7	16	14	19	32	39	44	43	51	54	58	104
Chemicals and allied products	483	604	773	834	1,580	1,870	2,037	2,349	2,627	2,782	3,220	3,656
Industrial chemicals	181	234	308	454	1,085	1,329	1,397	1,620	1,836	1,657	1,899	2,087
Drugs and medicines	175	194	264	234	316	371	459	529	563	958	1,091	1,299
Other chemicals	127	176	201	146	179	170	181	200	228	167	230	270
Primary metal industries	16	11	15	24	71	79	59	66	102	97	91	111
Fabricated metal products	21	16	30	21	20	28	82	54	64	76	67	112
Machinery, except electrical	69	94	129	189	284	297	350	355	342	286	476	562
Office and computing machines	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	370	401
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106	161
Electrical equipment	98	131	229	318	385	505	613	799	977	1,366	1,105	1,229
Transportation equipment	4	4	26	101	136	150	92	95	83	124	76	88
Professional and scientific instruments	15	18	28	32	52	47	42	42	58	112	279	225
Nonmanufacturing	82	131	134	D	212	356	301	314	374	413	637	635
Services	19	20	14	37	43	41	51	60	54	77	243	274
Other	63	111	120	D	169	315	250	254	320	336	394	361
Expenditures by country												
Canada	74	85	102	135	777	1,032	1,212	1,405	1,550	1,542	1,666	D
Europe	790	996	1,253	1,544	1,936	2,229	2,324	2,632	2,918	3,450	3,881	4,403
France	62	89	56	146	204	232	215	261	166	352	366	419
Germany	101	189	311	380	436	529	591	602	671	851	1,139	1,180
The Netherlands	190	215	244	299	373	397	387	432	514	517	542	597
Sweden	10	12	14	36	53	54	62	63	116	141	128	162
Switzerland	241	287	352	338	416	447	463	546	625	744	765	898
United Kingdom	155	176	252	312	405	520	559	664	748	764	833	1,042
Other European countries	31	28	24	33	49	50	47	64	78	81	108	105
Japan	23	54	77	88	142	141	171	210	267	292	307	515
Latin America	35	73	132	D	D	D	401	423	427	427	391	366
Rest of world	11	22	20	D	D	D	56	68	78	93	276	D
	Millions of constant 1982 U.S. dollars[1]											
TOTAL	1,387	1,703	2,016	2,270	3,310	3,744	4,009	4,398	4,723	5,099	5,553	6,084

D = withheld to avoid disclosing operations of individual companies
NA = not available

NOTE: Includes foreign direct investments of nonbank U.S. affiliates only.

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: U.S. Bureau of Economic Analysis, *Foreign Direct Investment in the United States* (Washington, DC: BEA, ongoing series).

See figure 4-16.

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Appendix table 5-1.
Expenditures for academic basic research, applied research, and development: 1960-91

	Total academic R&D	Basic research	Applied research	Development	Total academic R&D	Basic research	Applied research	Development	Basic research	Applied research	Development
	Millions of current dollars				Millions of constant 1982 dollars[1]				Percentage of total		
1960	646	433	179	34	2,077	1,392	575	109	67.0	27.7	5.3
1961	763	536	192	35	2,427	1,705	611	111	70.2	25.2	4.6
1962	904	659	205	40	2,825	2,060	641	125	72.9	22.7	4.4
1963	1,081	814	227	40	3,318	2,498	697	123	75.3	21.0	3.7
1964	1,275	1,003	232	40	3,858	3,035	702	121	78.7	18.2	3.1
1965	1,474	1,138	279	57	4,368	3,372	827	169	77.2	18.9	3.9
1966	1,715	1,303	328	84	4,937	3,751	944	242	76.0	19.1	4.9
1967	1,921	1,457	374	90	5,347	4,056	1,041	251	75.8	19.5	4.7
1968	2,149	1,650	403	96	5,778	4,437	1,084	258	76.8	18.8	4.5
1969	2,225	1,711	407	107	5,677	4,365	1,038	273	76.9	18.3	4.8
1970	2,335	1,796	427	112	5,629	4,329	1,029	270	76.9	18.3	4.8
1971	2,500	1,914	474	112	5,726	4,384	1,086	257	76.6	19.0	4.5
1972	2,630	2,022	524	84	5,710	4,390	1,138	182	76.9	19.9	3.2
1973	2,884	2,053	713	118	5,965	4,246	1,475	244	71.2	24.7	4.1
1974	3,022	2,153	736	133	5,794	4,128	1,411	255	71.2	24.4	4.4
1975	3,409	2,410	851	148	5,926	4,190	1,479	257	70.7	25.0	4.3
1976	3,729	2,549	1,016	164	6,007	4,106	1,637	264	68.4	27.2	4.4
1977	4,067	2,800	1,067	200	6,067	4,177	1,592	298	68.8	26.2	4.9
1978	4,625	3,176	1,213	236	6,449	4,428	1,691	329	68.7	26.2	5.1
1979	5,380	3,628	1,477	275	6,907	4,657	1,896	353	67.4	27.5	5.1
1980	6,077	4,041	1,698	338	7,171	4,769	2,004	399	66.5	27.9	5.6
1981	6,846	4,596	1,865	385	7,345	4,931	2,001	413	67.1	27.2	5.6
1982	7,323	4,882	2,037	404	7,323	4,882	2,037	404	66.7	27.8	5.5
1983	7,877	5,304	2,146	427	7,557	5,089	2,059	410	67.3	27.2	5.4
1984	8,617	5,735	2,459	423	7,965	5,301	2,273	391	66.6	28.5	4.9
1985	9,686	6,559	2,673	454	8,684	5,881	2,397	407	67.7	27.6	4.7
1986	10,926	7,495	2,911	520	9,542	6,545	2,542	454	68.6	26.6	4.8
1987	12,153	8,398	3,168	587	10,296	7,115	2,684	497	69.1	26.1	4.8
1988	13,465	8,827	3,993	645	11,072	7,258	3,283	530	65.6	29.7	4.8
1989	14,987	9,685	4,581	721	11,825	7,642	3,614	569	64.6	30.6	4.8
1990 (est.)	16,000	10,350	4,845	805	12,137	7,851	3,675	611	64.7	30.3	5.0
1991 (est.)	17,200	11,100	5,220	880	12,495	8,064	3,792	639	64.5	30.3	5.1

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1990*, NSF 90-316 (Washington, DC: NSF, 1990); and unpublished tabulations.

See figure 5-1.

Science & Engineering Indicators – 1991

Appendix table 5-2.
Support for academic R&D, by sector: 1960-91
(page 1 of 2)

Fiscal year	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
			Millions of current dollars			
1960	646	405	85	40	64	52
1961	763	500	95	40	70	58
1962	904	613	106	40	79	66
1963	1,081	760	118	41	89	73
1964	1,275	917	132	40	103	83
1965	1,474	1,073	143	41	124	93
1966	1,715	1,261	156	42	148	108
1967	1,921	1,409	164	48	181	119
1968	2,149	1,572	172	55	218	132
1969	2,225	1,600	197	60	223	145
1970	2,335	1,647	219	61	243	165
1971	2,500	1,724	255	70	274	177
1972	2,630	1,795	270	74	305	187
1973	2,884	1,985	295	84	318	202
1974	3,022	2,032	307	95	370	219
1975	3,409	2,288	332	113	417	259
1976	3,729	2,512	364	123	446	285
1977	4,067	2,726	374	139	514	314
1978[1]	4,625	3,059	412	170	625	359
1979	5,380	3,604	476	194	738	368
1980	6,077	4,104	496	236	837	403
1981	6,846	4,565	546	291	1,008	436
1982	7,323	4,763	616	337	1,115	492
1983	7,877	4,983	626	388	1,303	577
1984	8,617	5,423	690	475	1,413	615
1985	9,686	6,056	754	559	1,622	695
1986	10,926	6,702	916	699	1,873	735
1987	12,153	7,333	1,024	789	2,176	831
1988	13,465	8,181	1,107	870	2,367	941
1989	14,987	8,972	1,239	984	2,710	1,083
1990 (est.)[1]	16,000	9,250	1,396	1,100	3,054	1,200
1991 (est.)[1]	17,200	9,650	1,553	1,250	3,397	1,350
			Millions of constant 1982 dollars[2]			
1960	2,077	1,302	273	129	206	167
1961	2,427	1,590	302	127	223	184
1962	2,825	1,916	331	125	247	206
1963	3,318	2,332	362	126	273	224
1964	3,858	2,775	399	121	312	251
1965	4,368	3,179	424	121	367	276
1966	4,937	3,630	449	121	426	311
1967	5,347	3,922	457	134	504	331
1968	5,778	4,227	462	148	586	355
1969	5,677	4,082	503	153	569	370
1970	5,629	3,970	528	147	586	398
1971	5,726	3,949	584	160	628	405
1972	5,710	3,897	585	161	662	406
1973	5,965	4,106	609	174	658	418
1974	5,794	3,896	588	182	709	420
1975	5,926	3,978	577	196	726	450
1976	6,007	4,046	586	198	718	459
1977	6,067	4,067	558	207	767	468
1978[1]	6,449	4,265	574	237	871	501
1979	6,907	4,627	612	249	947	472

(continued)

Appendix table 5-2.

Support for academic R&D, by sector: 1960-91

(page 2 of 2)

Fiscal year	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
	Millions of constant 1982 dollars[2]					
1979	6,907	4,627	612	249	947	472
1980	7,171	4,843	586	278	988	476
1981	7,345	4,898	586	312	1,082	468
1982	7,323	4,763	616	337	1,115	492
1983	7,557	4,781	600	372	1,250	554
1984	7,965	5,012	638	439	1,306	568
1985	8,684	5,430	676	501	1,454	623
1986	9,542	5,853	800	610	1,636	642
1987	10,296	6,213	868	668	1,843	704
1988	11,072	6,727	910	715	1,946	774
1989	11,825	7,079	978	776	2,138	854
1990 (est.)[1]	12,137	7,017	1,059	834	2,316	910
1991 (est.)[1]	12,495	7,010	1,128	908	2,467	981
	Percent					
1960	100	62.7	13.2	6.2	9.9	8.0
1961	100	65.5	12.5	5.2	9.2	7.6
1962	100	67.8	11.7	4.4	8.7	7.3
1963	100	70.3	10.9	3.8	8.2	6.8
1964	100	71.9	10.4	3.1	8.1	6.5
1965	100	72.8	9.7	2.8	8.4	6.3
1966	100	73.5	9.1	2.4	8.6	6.3
1967	100	73.3	8.5	2.5	9.4	6.2
1968	100	73.2	8.0	2.6	10.1	6.1
1969	100	71.9	8.9	2.7	10.0	6.5
1970	100	70.5	9.4	2.6	10.4	7.1
1971	100	69.0	10.2	2.8	11.0	7.1
1972	100	68.3	10.3	2.8	11.6	7.1
1973	100	68.8	10.2	2.9	11.0	7.0
1974	100	67.2	10.2	3.1	12.2	7.2
1975	100	67.1	9.7	3.3	12.2	7.6
1976	100	67.4	9.8	3.3	11.9	7.6
1977	100	67.0	9.2	3.4	12.6	7.7
1978[1]	100	66.1	8.9	3.7	13.5	7.8
1979	100	67.0	8.9	3.6	13.7	6.8
1980	100	67.5	8.2	3.9	13.8	6.6
1981	100	66.7	8.0	4.3	14.7	6.4
1982	100	65.0	8.4	4.6	15.2	6.7
1983	100	63.3	7.9	4.9	16.5	7.3
1984	100	62.9	8.0	5.5	16.4	7.1
1985	100	62.5	7.8	5.8	16.7	7.2
1986	100	61.3	8.4	6.4	17.1	6.7
1987	100	60.3	8.4	6.5	17.9	6.8
1988	100	60.8	8.2	6.5	17.6	7.0
1989	100	59.9	8.3	6.6	18.1	7.2
1990 (est.)[1]	100	57.8	8.7	6.9	19.1	7.5
1991 (est.)[1]	100	56.1	9.0	7.3	19.7	7.8

[1] Relative amounts of funds from state and local governments and from academic institutions are estimated from previous year's ratio.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

See figures 5-1 and 5-2 and figure O-19 in Overview.

Science & Engineering Indicators – 1991

Appendix table 5-3.
Sources of R&D funds at private and public institutions, by sector: 1980 and 1989

Type of institution	Total	Federal Government	State and local government	Industry	Academic institutions	Other sources
	Thousands of dollars					
1980						
Private	2,213,087	1,744,398	44,048	94,954	164,580	165,107
Public	3,863,626	2,359,777	452,239	141,399	672,385	237,826
1989						
Private	5,164,603	3,787,343	125,730	358,983	454,901	437,648
Public	9,822,676	5,185,125	1,113,379	624,591	2,254,690	644,891
	Percent					
1980						
Private	100.0	78.8	2.0	4.3	7.4	7.5
Public	100.0	61.1	11.7	3.7	17.4	6.2
1989						
Private	100.0	73.3	2.4	7.0	8.8	8.5
Public	100.0	52.8	11.3	6.4	23.0	6.6

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989,* NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

Science & Engineering Indicators – 1991

Appendix table 5-4.
R&D expenditures at the top 100 universities and colleges, by source of funds: 1989
(page 1 of 3)

Academic institutions' ranking	Institutional category	Total	Federal Gov't	State and local gov't	Industry	Academic institutions	All other sources
		Thousands of dollars					
Total, all institutions[1]		14,556,179	8,550,551	1,238,860	983,574	2,700,657	1,082,539
1 Massachusetts Institute of Technology	Private	287,157	215,140	3,211	39,650	6,692	22,464
2 Cornell University	Private	286,733	157,984	40,405	16,627	49,157	22,560
3 Stanford University	Private	285,994	238,650	392	13,764	14,261	18,927
4 University of Wisconsin-Madison	Public	285,982	169,452	49,054	11,035	37,916	18,525
5 University of Michigan	Public	280,905	174,875	2,533	22,023	61,626	19,848
6 University of Minnesota	Public	258,614	132,880	42,542	12,389	43,713	27,090
7 Texas A & M University-all campuses	Public	250,706	93,584	65,179	21,204	63,053	7,686
8 University of California-Los Angeles	Public	227,828	159,002	3,479	7,548	32,975	24,824
9 University of Washington	Public	221,712	182,453	3,795	19,135	13,181	3,148
10 Pennsylvania State University-all campuses	Public	219,930	114,646	8,907	30,256	66,036	85
Total, 1st 10 institutions		2,605,561	1,638,666	219,497	193,631	388,610	165,157
11 University of California-San Francisco	Public	219,446	159,906	8,770	6,226	24,269	20,275
12 Johns Hopkins University[1]	Private	217,295	168,267	2,087	11,013	17,577	18,351
13 University of California-San Diego	Public	216,991	171,479	3,288	6,824	19,057	16,343
14 University of Illinois-Urbana	Public	210,590	114,398	25,838	15,785	47,336	7,233
15 University of California-Berkeley	Public	209,967	124,371	7,154	8,480	59,984	9,978
16 Harvard University	Private	209,519	143,451	1,135	10,461	16,602	37,870
17 University of Texas-Austin	Public	193,337	94,311	15,724	2,694	64,591	16,017
18 University of California-Davis	Public	180,297	72,718	10,322	8,039	79,601	9,617
19 Georgia Inst. of Technology-all campuses	Public	174,664	98,048	1,093	21,346	54,177	0
20 University of Arizona	Public	174,119	80,533	7,257	9,729	66,070	10,530
Total, 1st 20 institutions		4,611,786	2,866,148	302,165	294,228	837,874	311,371
21 University of Pennsylvania	Private	173,744	123,810	2,730	9,582	8,984	28,638
22 Columbia University	Private	172,145	146,712	2,461	5,408	4,189	13,375
23 Yale University	Private	171,139	138,835	920	6,563	9,736	15,085
24 Ohio State University-all campuses	Public	162,690	75,484	32,949	9,449	26,640	18,168
25 University of Southern California	Private	162,013	119,005	2,751	14,716	25,541	0
26 University of Maryland-College Park	Public	149,510	58,924	43,675	12,940	33,971	0
27 University of Georgia	Public	145,953	42,797	36,081	4,877	60,675	1,523
28 University of Colorado	Public	143,694	109,145	1,692	6,728	12,175	13,954
29 Baylor College of Medicine	Private	134,681	69,336	5,565	7,263	15,513	37,004
30 Duke University	Private	131,090	99,036	914	12,551	9,082	9,507
Total, 1st 30 institutions		6,158,445	3,849,232	431,903	384,305	1,044,380	448,625
31 North Carolina State University-Raleigh	Public	128,891	37,783	45,487	21,735	21,705	2,181
32 Washington University	Private	128,419	96,829	1,532	13,500	8,114	8,444
33 University of Florida	Public	125,770	60,731	10,180	10,579	38,144	6,136
34 University of Tennessee-System Office	Public	124,820	57,763	24,454	6,636	29,911	6,056
35 Rutgers State University of New Jersey	Public	124,574	35,896	26,369	6,087	50,305	5,917
36 Purdue University-all campuses	Public	124,323	63,979	17,641	11,451	25,954	5,298
37 University of Rochester	Private	123,997	101,049	6,088	4,913	2,779	9,168
38 Louisiana State University-all campuses	Public	122,357	40,114	37,182	2,120	32,750	10,191
39 University of North Carolina-Chapel Hill	Public	122,097	93,280	13,655	579	14,428	155
40 Michigan State University	Public	121,456	51,741	22,456	4,068	33,253	9,938

(continued)

Appendix table 5-4.
R&D expenditures at the top 100 universities and colleges, by source of funds: 1989
(page 2 of 3)

Academic institutions' ranking	Institutional category	Total	Federal Gov't	State and local gov't	Industry	Academic institutions	All other sources
		Thousands of dollars					
Total, 1st 40 institutions		7,405,149	4,488,397	636,947	465,973	1,301,723	512,109
41 Northwestern University	Private	118,991	57,510	831	5,289	45,008	10,353
42 University of Pittsburgh	Public	111,265	81,217	1,190	9,406	8,148	11,304
43 University of Massachusetts-System Office	Public	110,644	56,505	10,337	11,480	27,383	4,939
44 University of Chicago	Private	109,429	90,459	558	1,520	9,075	7,817
45 University of Connecticut	Public	109,328	46,184	4,249	4,996	46,208	7,691
46 University of Iowa	Public	105,900	74,271	1,121	10,301	18,102	2,105
47 New York University	Private	104,451	81,143	798	4,066	7,727	10,717
48 Virginia Polytechnic Inst. & State Univ.	Public	104,266	38,597	36,412	9,825	16,841	2,591
49 Iowa State University of Science & Tech.	Public	103,174	28,895	23,718	4,408	42,644	3,509
50 Carnegie-Mellon University	Private	101,635	65,079	9,277	18,976	1,844	6,459
Total, 1st 50 institutions		8,484,232	5,108,257	725,438	546,240	1,524,703	579,594
51 SUNY-Buffalo	Public	100,291	64,453	2,699	1,759	16,827	14,553
52 California Institute of Technology	Private	98,731	84,167	202	3,567	7,772	3,023
53 University of Alabama-Birmingham	Public	98,302	68,204	2,120	6,602	8,445	12,931
54 Oregon State University	Public	91,355	49,112	20,373	2,285	5,554	14,031
55 University of Miami (FL)	Private	90,298	63,101	1,546	4,702	5,604	15,345
56 Case Western Reserve University	Private	86,168	68,632	1,251	2,915	5,867	7,503
57 University of Texas-Cancer Ctr, MD Andrn	Public	85,903	28,992	0	0	35,200	21,711
58 University of Illinois-Chicago	Public	85,237	43,288	3,629	5,333	25,064	7,923
59 University of Utah	Public	83,340	61,819	3,511	2,700	11,259	4,051
60 Princeton University	Private	82,914	47,176	1,018	5,640	21,760	7,320
Total, 1st 60 institutions		9,386,771	5,687,201	761,787	581,743	1,668,055	687,985
61 Indiana University-all campuses	Public	81,793	58,334	833	2,591	15,120	4,915
62 University of Virginia	Public	81,281	51,214	7,006	5,768	10,196	7,097
63 University of Texas-Health Sci Ctr Dallas	Public	79,920	51,254	429	6,938	3,951	17,348
64 SUNY-Stony Brook	Public	79,455	49,726	2,534	3,093	16,710	7,392
65 University of Maryland-Baltimore	Public	75,854	35,970	14,047	11,183	9,488	5,166
66 Woods Hole Oceanographic Institute	Private	74,881	64,333	341	916	1,257	8,034
67 Yeshiva University	Private	74,496	58,224	0	0	8,022	8,250
68 University of Missouri-Columbia	Public	74,055	22,312	11,210	6,434	29,864	4,235
69 Rockefeller University	Private	73,945	41,192	297	3,453	17,442	11,561
70 University of Hawaii-Manoa	Public	70,733	40,574	24,759	799	3,686	915
Total, 1st 70 institutions		10,153,184	6,160,334	823,243	622,918	1,783,791	762,898
71 Utah State University	Public	69,944	42,449	12,125	1,315	13,087	968
72 University of Cincinnati-all campuses	Public	69,831	40,598	2,910	4,160	14,019	8,144
73 University of Kentucky	Public	69,532	27,010	6,840	5,819	25,318	4,545
74 University of Nebraska-Lincoln	Public	68,281	25,803	22,006	2,675	15,931	1,866
75 University of California-Irvine	Public	66,806	46,492	1,483	4,582	7,706	6,543
76 Boston University	Private	66,325	56,402	550	2,555	0	6,818
77 Vanderbilt University	Private	65,218	56,151	576	2,759	2,081	3,651
78 Emory University	Private	64,713	46,497	2,242	6,169	1,904	7,901
79 Colorado State University	Public	64,351	46,572	7,992	2,432	4,708	2,647
80 University of South Florida	Public	60,973	26,576	2,824	327	29,246	2,000

(continued)

Appendix table 5-4.

R&D expenditures at the top 100 universities and colleges, by source of funds: 1989

(page 3 of 3)

Academic institutions' ranking	Institutional category	Total	Federal Gov't	State and local gov't	Industry	Academic institutions	All other sources
		Thousands of dollars					
Total, 1st 80 institutions		10,819,158	6,574,884	882,791	655,711	1,897,791	807,981
81 New Mexico State University-all campuses	Public	60,930	45,660	7,070	6,242	1,727	231
82 Wayne State University	Public	59,521	28,167	7,042	3,850	15,507	4,955
83 University of Kansas	Public	57,111	26,420	2,674	2,809	23,640	1,568
84 CUNY-Mount Sinai School of Medicine	Private	56,856	37,233	957	3,732	5,767	9,167
85 University of Alaska-Fairbanks	Public	56,701	26,659	2,101	3,039	21,869	3,033
86 Clemson University	Public	56,699	12,484	16,245	3,849	22,486	1,635
87 Florida State University	Public	55,245	24,897	1,566	832	25,449	2,501
88 Washington State University	Public	55,173	22,697	2,268	2,258	22,945	5,005
89 University of Medicine & Dentistry of NJ	Public	54,451	27,983	9,421	2,583	9,166	5,298
90 University of Oklahoma	Public	53,956	17,020	3,052	1,991	24,226	7,667
Total, 1st 90 institutions		11,385,801	6,844,104	935,187	686,896	2,070,573	849,041
91 Auburn University-all campuses	Public	53,814	15,179	13,570	4,111	17,667	3,287
92 Mississippi State University	Public	53,670	17,694	20,334	3,886	5,416	6,340
93 Oklahoma State University	Public	53,655	14,116	1,853	1,645	34,613	1,428
94 Georgetown University	Private	53,597	37,351	217	4,370	8,278	3,381
95 University of California-Riverside	Public	53,213	15,584	2,441	1,094	31,449	2,645
96 University of New Mexico	Public	52,970	23,934	5,660	2,496	11,732	9,148
97 Tufts University	Private	50,424	40,771	773	8,010	847	23
98 University of California-Santa Barbara	Public	50,067	39,227	1,036	2,645	4,878	2,281
99 Kansas State Univ. of Agric. & Applied Sci	Public	47,302	15,951	21,133	1,790	6,384	2,044
100 Univ. of Texas-Health Science Ctr Houston	Public	46,860	29,500	5,668	3,266	1,694	6,732
Total, 1st 100 institutions		11,901,373	7,093,411	1,007,872	720,209	2,193,531	886,350

[1] These figures exclude the Applied Physics Laboratory (APL) at Johns Hopkins University, which is similar to a federally funded research and development center and dominates the R&D performed at the university.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See text table 5-1.

Science & Engineering Indicators – 1991

Appendix table 5-5.
Federal and non-Federal R&D expenditures at universities and colleges, by field and source of funds: 1989

	Total		Federal		Non-Federal[1]	
Field	Thousands of dollars	Percent	Thousands of dollars	Percent	Thousands of dollars	Percent
TOTAL SCIENCE AND ENGINEERING	14,987,279	100.0	8,972,468	59.9	6,014,811	40.1
Total sciences	12,599,686	84.1	7,592,804	60.3	5,006,882	39.7
Physical sciences	1,643,377	11.0	1,195,155	72.7	448,222	27.3
Astronomy	137,114	0.9	88,011	64.2	49,103	35.8
Chemistry	610,395	4.1	423,711	69.4	186,684	30.6
Physics	772,999	5.2	597,664	77.3	175,335	22.7
Other	122,869	0.8	85,769	69.8	37,100	30.2
Mathematical sciences	214,248	1.4	155,929	72.8	58,319	27.2
Computer sciences	467,729	3.1	317,882	68.0	149,847	32.0
Environmental sciences	982,937	6.6	644,691	65.6	338,246	34.4
Atmospheric sciences	159,084	1.1	124,894	78.5	34,190	21.5
Earth sciences	322,533	2.2	186,069	57.7	136,464	42.3
Oceanography	357,663	2.4	265,923	74.4	91,740	25.6
Other	143,657	1.0	67,805	47.2	75,852	52.8
Life sciences	8,079,851	53.9	4,772,841	59.1	3,307,010	40.9
Agricultural sciences	1,289,522	8.6	345,890	26.8	943,632	73.2
Biological sciences	2,609,759	17.4	1,719,858	65.9	889,901	34.1
Medical sciences	3,836,616	25.6	2,505,391	65.3	1,331,225	34.7
Other	343,954	2.3	201,702	58.6	142,252	41.4
Psychology	237,945	1.6	156,260	65.7	81,685	34.3
Social sciences	636,372	4.2	211,174	33.2	425,198	66.8
Economics	186,376	1.2	50,477	27.1	135,899	72.9
Political science	108,063	0.7	29,123	27.0	78,940	73.0
Sociology	118,554	0.8	52,802	44.5	65,752	55.5
Other	223,379	1.5	78,772	35.3	144,607	64.7
Other sciences	337,227	2.3	138,872	41.2	198,355	58.8
Total engineering	2,387,593	15.9	1,379,664	57.8	1,007,929	42.2
Aeronautical/astronautical	146,548	1.0	113,109	77.2	33,439	22.8
Chemical	185,087	1.2	92,947	50.2	92,140	49.8
Civil	249,552	1.7	104,108	41.7	145,444	58.3
Electrical/electronic	600,016	4.0	388,700	64.8	211,316	35.2
Mechanical	340,280	2.3	209,711	61.6	130,569	38.4
Other	866,110	5.8	471,089	54.4	395,021	45.6

[1] See appendix table 5-2 for detail on non-Federal sources.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

Science & Engineering Indicators – 1991

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Appendix table 5-6.
Expenditures for academic R&D, by field: 1979-89
(page 1 of 3)

Field	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Thousands of current dollars										
TOTAL SCIENCE & ENGINEERING	5,379,917	6,076,713	6,846,302	7,322,745	7,876,861	8,616,682	9,686,358	10,925,519	12,153,437	13,465,094	14,987,279
Total sciences	4,604,364	5,203,539	5,869,568	6,281,886	6,746,534	7,387,668	8,271,436	9,287,291	10,265,945	11,373,904	12,599,686
Physical sciences	602,106	677,407	765,358	823,363	899,695	999,672	1,147,733	1,285,972	1,390,942	1,547,216	1,643,377
Astronomy	48,492	58,625	67,259	73,125	73,442	80,474	96,083	101,795	108,429	124,438	137,114
Chemistry	206,353	243,943	284,696	308,058	334,982	371,484	421,023	469,275	513,102	567,822	610,395
Physics	292,366	322,760	357,151	366,833	417,037	473,591	550,834	630,244	666,568	732,486	772,999
Other	54,895	52,079	56,252	75,347	74,234	74,123	79,793	84,658	102,843	122,470	122,869
Mathematical sciences	77,822	78,108	87,099	96,459	106,440	123,261	128,031	151,904	176,871	198,833	214,248
Computer sciences	97,701	113,390	132,542	149,101	175,902	224,637	282,722	322,874	373,086	410,839	467,729
Environmental sciences	452,831	508,262	549,273	557,353	615,892	643,946	703,180	772,605	830,819	884,522	982,937
Atmospheric sciences	NA	75,898	87,357	86,668	98,636	102,010	107,696	120,057	128,345	133,668	159,084
Earth sciences	NA	188,570	190,238	195,272	216,245	227,768	253,931	274,525	284,091	294,559	322,533
Oceanography	NA	176,313	191,995	198,202	223,931	236,784	257,973	279,992	299,949	333,282	357,663
Other	452,831	67,481	79,683	77,211	77,080	77,384	83,580	98,031	118,434	123,013	143,657
Life sciences	2,847,512	3,230,619	3,698,138	4,016,113	4,303,519	4,712,815	5,282,032	5,892,653	6,532,724	7,257,860	8,079,851
Agricultural sciences	612,256	689,127	789,574	864,681	921,445	954,565	999,674	1,089,949	1,120,938	1,181,841	1,289,522
Biological sciences	912,418	1,027,542	1,185,643	1,282,740	1,414,501	1,567,350	1,774,357	1,937,994	2,132,208	2,372,832	2,609,759
Medical sciences	1,246,579	1,422,915	1,612,621	1,745,615	1,835,875	2,040,616	2,327,268	2,625,341	3,015,867	3,387,914	3,836,616
Other	76,259	91,035	110,300	123,077	131,698	150,284	180,733	239,369	263,711	315,273	343,954
Psychology	99,694	110,108	126,935	130,609	135,669	145,525	158,534	170,705	187,881	213,989	237,945
Social sciences	293,245	339,550	365,648	353,023	344,642	358,317	382,844	462,472	502,098	553,238	636,372
Economics	83,349	90,942	98,800	95,116	98,088	108,494	117,988	135,766	149,685	164,142	186,376
Political science	44,641	54,476	55,403	60,213	54,624	56,110	59,379	68,835	81,221	87,027	108,063
Sociology	74,309	87,699	93,955	78,805	77,102	70,319	75,334	96,608	96,627	110,580	118,554
Other	90,946	106,433	117,490	118,889	114,828	123,394	130,143	161,263	174,565	191,489	223,379
Other sciences	133,453	146,095	144,575	155,865	164,775	179,495	186,360	228,106	271,524	307,407	337,227

(continued)

Appendix table 5-6.

Expenditures for academic R&D, by field: 1979-89

(page 2 of 3)

Field	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Thousands of current dollars										
Total engineering	775,553	873,174	976,734	1,040,859	1,130,327	1,229,014	1,414,922	1,638,228	1,887,492	2,091,190	2,387,593
Aeronautical/astronautical	NA	53,096	58,532	65,160	69,916	71,831	82,229	93,530	110,065	124,737	146,548
Chemical	NA	60,874	79,235	83,808	91,174	96,095	109,782	126,197	140,649	154,169	185,087
Civil	NA	83,231	108,608	115,800	126,465	139,609	153,141	178,745	192,334	226,832	249,552
Electrical/electronic	NA	193,976	203,569	224,461	261,809	294,836	337,479	394,904	449,770	507,894	600,016
Mechanical	NA	140,335	140,582	142,388	148,820	178,361	206,894	227,031	273,340	300,886	340,280
Other	NA	341,662	386,208	409,242	432,143	448,282	525,397	617,821	721,334	776,672	866,110
	Thousands of constant 1982 dollars[1]										
TOTAL SCIENCE & ENGINEERING	6,906,546	7,170,942	7,345,364	7,322,745	7,557,012	7,964,282	8,684,745	9,541,111	10,296,590	11,071,623	11,825,067
Total sciences	5,910,919	6,140,537	6,297,431	6,281,886	6,472,583	6,828,321	7,416,133	8,110,468	8,697,476	9,352,150	9,941,240
Physical sciences	772,962	799,387	821,149	823,363	863,162	923,983	1,029,052	1,123,022	1,178,429	1,272,193	1,296,636
Astronomy	62,252	69,182	72,162	73,125	70,460	74,381	86,148	88,896	91,863	102,319	108,184
Chemistry	264,909	287,870	305,449	308,058	321,380	343,358	377,487	409,812	434,708	466,890	481,606
Physics	375,329	380,879	383,186	366,833	400,103	437,734	493,875	550,384	564,727	602,284	609,902
Other	70,472	61,457	60,352	75,347	71,220	68,511	71,542	73,931	87,130	100,701	96,944
Mathematical sciences	99,905	92,173	93,448	96,459	102,118	113,928	114,792	132,656	149,848	163,490	169,043
Computer sciences	125,425	133,808	142,204	149,101	168,759	207,629	253,487	281,962	316,085	337,811	369,041
Environmental sciences	581,328	599,784	589,312	557,353	590,883	595,191	630,468	674,706	703,883	727,295	775,544
Atmospheric sciences	NA	89,565	93,725	86,668	94,631	94,286	96,560	104,844	108,736	109,908	125,518
Earth sciences	NA	222,526	204,105	195,272	207,464	210,523	227,673	239,739	240,687	242,200	254,481
Oceanography	NA	208,062	205,991	198,202	214,838	218,856	231,297	244,513	254,122	274,040	282,199
Other	581,328	79,632	85,492	77,211	73,950	71,525	74,937	85,609	100,339	101,147	113,346
Life sciences	3,655,535	3,812,354	3,967,714	4,016,113	4,128,770	4,355,991	4,735,846	5,145,976	5,534,630	5,967,748	6,375,059
Agricultural sciences	785,992	813,218	847,130	864,681	884,029	882,291	896,303	951,838	949,677	971,764	1,017,442
Biological sciences	1,171,330	1,212,571	1,272,071	1,282,740	1,357,064	1,448,680	1,590,881	1,692,425	1,806,441	1,951,052	2,059,118
Medical sciences	1,600,314	1,679,138	1,730,173	1,745,615	1,761,327	1,886,114	2,086,618	2,292,676	2,555,092	2,785,700	3,027,117
Other	97,899	107,428	118,340	123,077	126,350	138,905	162,044	209,038	223,420	259,232	271,382
Psychology	127,984	129,935	136,188	130,609	130,160	134,507	142,141	149,074	159,176	175,952	187,740
Social sciences	376,458	400,693	392,302	353,023	330,647	331,188	343,256	403,871	425,386	454,898	502,102
Economics	107,000	107,318	106,002	95,116	94,105	100,280	105,788	118,563	126,816	134,965	147,052
Political science	57,309	64,285	59,442	60,213	52,406	51,862	53,239	60,113	68,812	71,558	85,262
Sociology	95,395	103,491	100,804	78,805	73,971	64,995	67,544	84,366	81,864	90,924	93,540
Other	116,753	125,598	126,054	118,889	110,165	114,051	116,686	140,829	147,894	157,451	176,248
Other sciences	171,322	172,402	155,114	155,865	158,084	165,905	167,090	199,202	230,040	252,764	266,074

(continued)

Appendix table 5-6.

Expenditures for academic R&D, by field: 1979-89

(page 3 of 3)

Field	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Thousands of constant 1982 dollars[1]										
Total engineering	995,627	1,030,406	1,047,933	1,040,859	1,084,429	1,135,961	1,268,613	1,430,643	1,599,114	1,719,473	1,883,827
Aeronautical/astronautical	NA	62,657	62,799	65,160	67,077	66,392	73,726	81,679	93,249	102,565	115,627
Chemical	NA	71,836	85,011	83,808	87,472	88,819	98,430	110,206	119,160	126,765	146,035
Civil	NA	98,218	116,525	115,800	121,330	129,039	137,306	156,096	162,948	186,512	196,898
Electrical/electronic	NA	228,905	218,408	224,461	251,178	272,513	302,582	344,864	381,052	417,614	473,417
Mechanical	NA	165,605	150,830	142,388	142,777	164,857	185,500	198,263	231,578	247,402	268,483
Other	NA	403,185	414,361	409,242	414,595	414,341	471,069	539,535	611,126	638,616	683,367

NA = not available

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

See figure 5-3.

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Appendix table 5-7
Federal financing of academic R&D funds, by field: 1973-89

Field	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Percentage federally financed																
TOTAL SCIENCE AND ENGINEERING	68.8	67.2	67.1	67.4	67.0	66.2	67.0	67.5	66.7	65.0	63.3	62.9	62.5	61.3	60.3	60.8	59.9
Physical sciences	81.8	81.0	81.4	80.5	80.0	79.6	81.5	81.9	80.8	78.9	77.7	78.2	77.5	76.4	75.3	74.6	72.7
Astronomy	73.4	70.0	73.4	69.8	71.8	71.6	74.8	75.6	71.0	70.6	68.0	66.1	67.0	68.5	65.7	65.5	64.2
Chemistry	76.1	76.6	76.8	77.0	76.2	75.8	75.8	77.7	76.0	74.7	73.8	75.1	74.2	72.0	71.7	71.3	69.4
Physics	87.1	86.6	86.4	85.3	85.2	84.9	86.4	86.8	86.5	83.6	82.1	82.4	82.3	81.0	79.7	78.6	77.3
Other	79.7	74.4	77.7	77.2	73.7	72.6	82.7	78.7	81.1	81.2	80.4	80.1	75.0	75.8	75.1	74.7	69.8
Math and computer sciences	73.8	75.7	76.3	75.6	72.5	68.6	73.9	72.0	73.4	72.8	72.3	73.3	71.2	73.1	70.6	71.9	69.5
Mathematical sciences	77.5	78.4	78.6	77.4	77.7	75.7	77.6	78.4	77.7	74.4	71.8	74.9	75.8	75.3	74.3	75.0	72.8
Computer sciences	69.9	73.2	74.3	74.0	67.6	62.2	70.9	67.6	70.5	71.7	72.6	72.5	69.2	72.0	68.9	70.4	68.0
Environmental sciences	75.2	71.7	70.8	73.4	74.7	72.7	72.6	73.2	71.1	70.1	69.1	69.1	67.2	66.7	65.1	65.9	65.6
Atmospheric sciences	NA	NA	NA	NA	NA	NA	NA	84.2	77.0	80.0	78.5	80.8	79.9	81.3	82.5	81.7	78.5
Earth sciences	NA	NA	NA	NA	NA	NA	NA	69.7	67.2	65.0	62.4	61.5	60.7	58.3	56.2	59.2	57.7
Oceanography	NA	NA	NA	NA	NA	NA	NA	77.6	77.9	77.4	76.6	76.4	72.7	74.3	72.6	71.6	74.4
Other	75.2	71.7	70.8	73.4	74.7	72.7	72.6	58.7	57.7	53.2	54.0	53.8	53.6	50.1	48.7	49.2	47.2
Life sciences	66.3	64.5	65.1	65.7	65.3	63.9	64.0	64.8	63.9	62.3	60.1	60.0	60.3	59.2	58.6	59.5	59.1
Agricultural sciences	34.1	29.2	29.4	29.7	28.8	29.2	30.5	31.1	29.7	29.5	28.4	28.2	29.4	26.8	26.5	27.3	26.8
Biological sciences	71.6	71.7	72.5	73.5	74.5	72.8	72.6	74.0	73.0	71.4	69.5	69.5	67.9	67.4	66.2	67.0	65.9
Medical sciences	75.3	75.9	75.6	75.5	74.9	73.1	73.7	74.4	73.7	71.7	68.7	67.3	67.8	66.4	65.1	65.4	65.3
Other	70.3	72.5	71.8	72.6	71.7	70.6	70.1	67.4	67.6	63.8	60.8	62.8	60.0	61.3	59.7	60.1	58.6
Psychology	79.5	78.9	76.8	76.2	74.8	71.4	72.3	73.3	72.7	68.2	66.1	67.4	67.0	67.0	66.1	65.8	65.7
Social sciences	57.3	56.9	55.2	52.7	51.6	51.1	53.0	53.8	51.0	45.7	42.6	39.9	40.1	37.4	33.5	34.0	33.2
Economics	47.6	46.6	48.2	44.5	43.8	48.1	48.4	48.9	45.4	43.7	39.5	39.1	37.0	33.5	29.0	30.0	27.1
Political science	40.6	44.0	41.8	42.2	46.2	42.1	46.0	43.4	42.0	37.3	36.8	33.9	33.3	29.5	29.7	28.9	27.0
Sociology	65.8	65.1	65.5	62.1	61.1	61.0	63.7	65.0	60.7	58.6	55.6	54.3	53.3	51.3	46.6	44.4	44.5
Other	61.0	60.0	55.9	54.8	52.9	50.6	51.9	54.0	52.3	42.9	39.3	35.1	38.4	35.6	31.9	33.9	35.3
Other sciences	58.7	57.1	57.2	59.5	54.9	57.4	54.9	53.6	56.6	56.5	52.7	48.5	49.3	47.1	46.0	43.4	41.2
Engineering	71.5	69.0	68.1	67.3	67.6	67.9	68.7	69.0	68.7	67.6	65.9	64.0	61.2	59.6	58.7	58.6	57.8
Aeronautical/astronautical	NA	NA	NA	NA	NA	NA	NA	79.5	81.8	80.6	80.4	79.4	78.5	78.8	76.0	77.8	77.2
Chemical	NA	NA	NA	NA	NA	NA	NA	64.4	64.0	59.7	57.6	57.1	53.4	53.6	49.5	50.6	50.2
Civil	NA	NA	NA	NA	NA	NA	NA	64.1	56.8	51.4	50.4	51.9	51.6	49.7	47.1	46.1	41.7
Electrical/electronic	NA	NA	NA	NA	NA	NA	NA	77.1	76.6	77.4	73.8	71.0	67.7	65.9	64.7	64.8	64.8
Mechanical	NA	NA	NA	NA	NA	NA	NA	67.0	67.5	68.4	67.2	66.5	64.6	64.9	64.8	63.3	61.6
Other	NA	NA	NA	NA	NA	NA	NA	65.7	67.4	66.1	64.5	61.2	57.3	54.7	55.0	54.8	54.4

NA = not available

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

Appendix table 5-8.
Federal obligations for academic R&D, by agency: 1971-91
(page 1 of 2)

	Total agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aero & Space Administration	Department of Energy[1]	Department of Agriculture	All other agencies
	Millions of current dollars							
1971	1,645	603	267	211	134	94	72	264
1972	1,904	756	362	217	119	85	87	277
1973	1,917	761	374	204	111	83	94	289
1974	2,214	1,027	389	197	99	94	95	312
1975	2,411	1,077	435	203	108	132	108	348
1976	2,552	1,185	437	240	119	145	120	307
1977	2,905	1,311	511	273	118	188	140	364
1978	3,375	1,493	537	383	127	240	186	408
1979	3,889	1,765	617	438	139	260	200	470
1980	4,263	1,888	685	495	158	285	216	536
1981	4,466	1,984	702	573	171	300	243	492
1982	4,605	2,026	715	664	186	277	255	483
1983	4,966	2,264	783	724	189	297	275	434
1984	5,547	2,560	880	830	204	321	261	491
1985	6,340	2,974	1,002	940	237	357	293	536
1986	6,559	3,044	992	1,098	254	345	274	553
1987	7,337	3,638	1,096	1,017	294	386	280	626
1988	7,828	3,886	1,143	1,071	338	406	305	678
1989	8,672	4,157	1,254	1,189	434	454	328	858
1990 (est.)	8,748	4,143	1,317	1,049	493	441	346	959
1991 (est.)	9,191	4,339	1,478	1,069	533	429	364	980
	Millions of constant 1982 dollars[2]							
1971	3,767	1,382	611	483	307	215	165	604
1972	4,133	1,641	787	471	258	183	190	602
1973	3,964	1,574	775	421	230	171	195	598
1974	4,245	1,969	746	378	190	180	182	599
1975	4,207	1,878	759	355	188	230	189	608
1976	4,111	1,908	703	387	192	234	193	494
1977	4,335	1,956	762	408	175	281	209	543
1978	4,705	2,082	749	534	177	335	260	568
1979	4,992	2,266	792	562	178	334	256	604
1980	5,031	2,228	808	585	186	336	255	633
1981	4,791	2,129	753	615	184	322	260	528
1982	4,605	2,026	715	664	186	277	255	483
1983	4,765	2,172	751	695	182	285	264	416
1984	5,127	2,366	814	767	188	297	241	454
1985	5,684	2,667	898	843	213	320	263	481
1986	5,728	2,658	866	959	222	301	239	483
1987	6,216	3,083	929	862	249	327	237	530
1988	6,436	3,195	940	881	278	334	251	558
1989	6,842	3,280	989	938	342	358	259	677
1990 (est.)	6,636	3,143	999	796	374	335	262	727
1991 (est.)	6,676	3,152	1,073	777	387	312	264	712

(continued)

Appendix table 5-8.

Federal obligations for academic R&D, by agency: 1971-91

(page 2 of 2)

	Total agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aero & Space Administration	Department of Energy[1]	Department of Agriculture	All other agencies
	Percent							
1971	100	36.7	16.2	12.8	8.2	5.7	4.4	16.0
1972	100	39.7	19.0	11.4	6.3	4.4	4.6	14.6
1973	100	39.7	19.5	10.6	5.8	4.3	4.9	15.1
1974	100	46.4	17.6	8.9	4.5	4.2	4.3	14.1
1975	100	44.6	18.0	8.4	4.5	5.5	4.5	14.4
1976	100	46.4	17.1	9.4	4.7	5.7	4.7	12.0
1977	100	45.1	17.6	9.4	4.0	6.5	4.8	12.5
1978	100	44.2	15.9	11.4	3.8	7.1	5.5	12.1
1979	100	45.4	15.9	11.3	3.6	6.7	5.1	12.1
1980	100	44.3	16.1	11.6	3.7	6.7	5.1	12.6
1981	100	44.4	15.7	12.8	3.8	6.7	5.4	11.0
1982	100	44.0	15.5	14.4	4.0	6.0	5.5	10.5
1983	100	45.6	15.8	14.6	3.8	6.0	5.5	8.7
1984	100	46.2	15.9	15.0	3.7	5.8	4.7	8.8
1985	100	46.9	15.8	14.8	3.7	5.6	4.6	8.5
1986	100	46.4	15.1	16.7	3.9	5.3	4.2	8.4
1987	100	49.6	14.9	13.9	4.0	5.3	3.8	8.5
1988	100	49.6	14.6	13.7	4.3	5.2	3.9	8.7
1989	100	47.9	14.5	13.7	5.0	5.2	3.8	9.9
1990 (est.)	100	47.4	15.1	12.0	5.6	5.0	3.9	11.0
1991 (est.)	100	47.2	16.1	11.6	5.8	4.7	4.0	10.7

NOTE: Percentages may not total 100 because of rounding.

[1] Atomic Energy Commission, 1971-73; Energy Research and Development Administration, 1974-76; Department of Energy, 1977-91.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327 Final, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

Science & Engineering Indicators – 1991

Appendix table 5-9.
Federal academic R&D obligations, by lead agency and field: 1971-89
(page 1 of 2)

Field	Lead agency	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Percentage from lead agency																		
TOTAL SCIENCE AND ENGINEERING	HHS	44.8	47.4	48.3	54.1	53.7	53.3	51.8	49.0	50.8	48.7	47.9	46.3	47.0	49.2	49.6	49.7	53.0	53.5	53.0
Physical sciences	NSF	20.4	27.9	29.0	31.6	35.9	36.2	35.2	34.5	36.6	35.6	32.9	37.2	36.6	39.0	38.8	37.0	36.9	36.5	35.8
Astronomy	NASA	74.7	74.5	73.3	69.8	67.2	65.1	59.8	61.3	66.9	69.9	74.1	64.3	66.3	65.1	61.8	62.8	64.9	65.8	68.6
Chemistry	NSF	25.2	32.6	32.0	30.6	38.9	37.0	36.5	35.6	37.7	37.8	33.8	36.3	36.9	38.9	38.9	37.5	38.7	38.9	39.8
Physics	DOE	30.0	30.3	30.0	34.4	34.8	33.7	38.8	39.5	41.8	42.2	45.8	44.7	46.7	46.5	45.7	44.1	43.6	43.3	41.3
Other	NSF	0.0	1.0	1.4	2.1	40.1	46.1	35.9	49.4	50.4	67.9	72.8	79.4	77.4	77.4	71.8	72.7	70.6	69.9	71.0
Math and computer sciences	NSF	39.5	43.9	47.3	45.7	45.4	40.4	48.9	50.6	57.6	50.2	52.4	50.8	50.9	53.8	53.4	53.4	53.1	50.8	54.0
Mathematical sciences	NSF	NA	NA	NA	NA	NA	NA	41.8	50.6	53.2	46.0	49.1	47.6	47.7	50.3	49.2	52.5	55.1	55.4	60.4
Computer sciences	NSF	NA	NA	NA	NA	NA	NA	62.0	52.3	66.2	58.4	61.3	56.8	56.4	59.4	58.4	56.7	52.6	45.9	48.5
Environmental sciences	NSF	32.5	41.4	44.2	48.4	50.1	48.1	39.1	39.1	38.9	37.5	42.1	43.5	45.5	44.7	42.0	41.1	41.0	41.0	40.2
Atmospheric sciences	NSF	31.0	35.4	41.2	38.0	46.0	45.2	29.7	33.4	32.5	38.6	34.9	36.9	38.9	41.1	35.0	38.0	41.5	36.4	37.8
Earth sciences	NSF	22.0	31.1	29.0	31.7	41.5	49.1	41.3	41.5	47.6	51.0	56.7	60.4	66.7	62.0	60.1	59.0	57.6	52.0	50.6
Oceanography	NSF	44.5	60.4	59.4	66.8	35.8	39.1	38.4	32.1	30.4	31.1	31.5	31.3	30.1	30.2	32.8	36.0	28.8	35.6	35.6
Other	NSF	27.8	24.8	30.3	43.4	74.8	63.1	51.5	52.7	42.6	26.9	46.5	46.7	54.4	58.1	43.3	30.5	38.3	39.2	35.6
Life sciences	HHS	76.4	79.3	79.6	82.6	82.3	81.4	82.1	80.6	80.6	81.3	79.9	77.7	79.6	80.6	80.5	81.1	82.8	83.8	83.6
Agricultural sciences	USDA	NA	NA	NA	NA	NA	NA	NA	NA	80.3	86.4	81.5	75.9	79.2	72.7	76.5	78.4	77.2	83.7	78.4
Biological sciences	HHS	63.4	61.8	62.5	66.8	66.3	67.1	67.8	71.0	80.0	82.3	81.3	81.7	83.4	80.8	81.5	81.5	83.4	83.9	82.8
Medical sciences	HHS	95.1	94.8	96.0	96.6	96.5	96.8	96.8	95.9	94.4	92.8	92.4	88.3	90.0	92.3	91.9	92.0	93.1	93.4	94.6
Psychology	HHS	59.2	60.5	63.6	65.5	75.0	75.7	72.1	68.6	77.2	74.9	75.6	77.7	77.9	78.7	79.2	80.8	83.3	84.2	85.6
Social sciences	HHS	37.7	43.8	41.9	42.7	54.4	41.6	43.3	47.9	58.3	31.5	29.4	28.4	27.3	33.6	33.7	33.6	42.2	44.6	49.0
Economics	USDA	43.1	8.1	9.7	7.2	4.3	3.0	4.0	40.8	41.4	40.2	45.6	56.3	59.9	54.6	46.4	47.8	44.1	55.0	50.6
Political science	NSF	46.0	55.2	59.1	53.6	44.0	52.3	59.8	66.7	51.8	71.8	60.1	81.3	61.2	48.2	60.3	47.4	54.4	52.3	45.9
Sociology	HHS	40.7	45.5	47.9	55.7	71.0	57.3	52.5	42.0	57.5	48.5	63.5	61.0	67.7	66.3	62.5	58.1	69.3	75.5	75.1
Anthropology	NSF	69.1	77.4	87.4	72.8	76.2	70.5	67.4	47.6	58.3	59.2	78.2	93.8	96.8	88.7	91.5	88.2	70.7	73.5	89.4
Linguistics	NSF	29.2	51.7	47.2	66.8	50.3	61.5	65.4	65.3	67.5	72.8	72.1	88.8	90.8	94.8	95.5	94.5	92.3	86.8	77.9
History of science	NSF	85.0	49.5	93.5	80.1	86.4	99.3	87.6	89.9	89.9	76.4	86.1	98.4	93.9	96.9	97.9	94.0	88.2	89.7	91.2
Other	HHS	54.4	57.5	55.6	49.7	68.6	54.5	54.9	88.4	92.4	42.5	32.7	68.1	41.4	38.8	39.1	40.3	57.7	54.9	56.2
Other sciences	HHS	40.3	49.8	37.2	43.2	48.9	58.9	66.6	58.9	51.1	45.2	53.5	43.3	51.6	44.2	49.9	40.6	37.8	30.1	33.1

(continued)

Appendix table 5-9.

Federal academic R&D obligations, by lead agency and field: 1971-89

(page 2 of 2)

Field	Lead agency	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Percentage from lead agency																		
Engineering	DOD	45.2	40.3	42.1	30.7	27.9	26.6	30.2	53.8	61.4	55.4	62.1	67.4	67.4	61.3	62.7	65.6	66.5	66.9	61.2
Aeronautical/astronautical	DOD	14.1	30.8	13.1	42.1	31.9	22.0	32.9	47.0	56.4	49.9	49.7	57.5	62.7	55.0	57.4	58.3	55.6	54.5	51.7
Chemical	NSF	71.1	51.0	48.2	62.4	60.7	40.2	27.4	22.1	51.9	53.8	52.6	50.7	43.8	44.2	39.1	55.0	51.7	41.1	74.2
Civil	NSF	36.5	37.9	29.1	38.6	32.5	44.0	48.1	42.9	45.5	40.1	30.5	53.6	43.1	49.8	68.9	68.1	64.6	63.2	53.5
Electrical/electronic	DOD	80.4	76.2	77.3	61.6	58.3	44.0	50.3	59.4	62.5	68.4	72.2	79.2	81.5	75.6	83.5	82.0	81.4	86.1	78.1
Mechanical	NSF	40.6	33.8	52.4	52.5	45.6	32.0	30.3	25.9	35.3	22.7	26.9	34.1	34.7	36.6	35.2	40.9	34.3	36.8	48.4
Materials/metallurgy	NSF	16.3	57.4	55.9	56.1	35.6	39.4	37.1	33.1	40.2	26.0	33.8	30.0	30.1	30.8	33.8	28.0	20.9	16.4	18.1
Other	DOD	19.3	25.2	40.2	17.1	19.3	20.2	25.8	71.6	77.5	75.8	78.4	80.0	81.3	79.7	77.9	80.4	82.6	80.4	73.4

NOTE: DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture.

[1] NASA provided over 80 percent of the Federal academic R&D obligations for aerospace engineering in the 1970s; this field is now split between NASA and DOD.

SOURCES: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1989, 1990, and 1991*, NSF 90-327 Final, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

See figure 5-4.

Science & Engineering Indicators – 1991

Appendix table 5-10.

Capital funds expenditures for academic facilities and certain equipment: 1964-89

	Total		Federal sources		Non-Federal sources	
	Current dollars	Constant 1982 dollars[1]	Current dollars	Constant 1982 dollars[1]	Current dollars	Constant 1982 dollars[1]
	Thousands of dollars					
1964	529,492	1,602,094	134,439	406,775	395,053	1,195,319
1965	NA	NA	NA	NA	NA	NA
1966	666,997	1,919,968	212,397	611,390	454,600	1,308,578
1967	NA	NA	NA	NA	NA	NA
1968	1,070,727	2,879,072	340,447	915,426	730,280	1,963,646
1969	NA	NA	NA	NA	NA	NA
1970	951,873	2,294,776	279,316	673,375	672,557	1,621,401
1971	NA	NA	NA	NA	NA	NA
1972	912,487	1,981,034	236,836	514,177	675,651	1,466,856
1973	835,862	1,728,790	224,651	464,639	611,211	1,264,151
1974	841,560	1,613,521	225,681	432,698	615,879	1,180,823
1975	1,018,773	1,771,062	270,083	469,519	748,690	1,301,542
1976	1,043,153	1,680,342	206,890	333,265	836,263	1,347,078
1977	960,014	1,432,190	195,519	291,684	764,495	1,140,506
1978	NA	NA	NA	NA	NA	NA
1979	694,583	891,681	169,419	217,494	525,164	674,187
1980	790,040	932,302	147,590	174,166	642,450	758,136
1981	953,529	1,023,037	160,557	172,261	792,972	850,776
1982	964,596	964,596	126,448	126,448	838,148	838,148
1983	1,091,753	1,047,421	135,101	129,615	956,652	917,806
1984	1,174,646	1,085,709	142,440	131,655	1,032,206	954,054
1985	1,222,698	1,096,266	106,801	95,757	1,115,897	1,000,508
1986	1,493,503	1,304,256	170,509	148,903	1,322,994	1,155,353
1987	1,737,118	1,471,715	193,246	163,721	1,543,872	1,307,993
1988	1,954,626	1,607,184	202,034	166,122	1,752,592	1,441,062
1989	2,091,699	1,650,365	205,769	162,353	1,885,930	1,488,012

NA = not available

NOTE: Data are for expenditures on facilities used for research, development, and instruction, and for expenditures on nonfixed equipment costing over $1 million.

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

See figure 5-5 and figure O-20 in Overview. *Science & Engineering Indicators – 1991*

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Appendix table 5-11.

Capital expenditures at universities and colleges, by field and source of funds: 1980-89

(page 1 of 2)

Field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Thousands of current dollars									
TOTAL	790,040	953,529	964,596	1,091,753	1,174,646	1,222,698	1,493,503	1,737,118	1,954,626	2,091,699
Total sciences	700,088	848,037	817,600	954,918	1,027,762	1,039,100	1,179,354	1,357,333	1,589,311	1,719,874
Physical sciences	77,567	88,880	83,296	97,864	110,134	115,653	143,667	156,849	204,919	237,669
Math and computer sciences	32,923	31,904	35,651	54,206	48,921	77,209	90,603	82,651	95,412	72,672
Environmental sciences	36,727	36,790	44,006	42,174	36,218	54,574	48,945	54,063	58,676	67,518
Life sciences	452,522	591,395	578,398	667,367	716,602	691,149	768,281	908,977	1,050,025	1,161,852
Pyschology	17,970	11,139	12,956	16,705	31,317	12,807	17,816	9,669	12,130	13,894
Social sciences	34,956	45,702	31,344	40,898	46,941	60,720	49,919	55,207	80,709	77,483
Other sciences	47,423	42,227	31,949	35,704	37,629	26,988	60,123	89,917	87,440	88,786
Engineering	89,952	105,492	146,996	136,835	146,884	183,598	314,149	379,785	365,315	371,825
Federal sources	147,590	160,557	126,448	135,101	142,440	106,801	170,509	193,246	202,034	205,769
Total sciences	126,335	141,436	105,517	116,711	111,800	90,008	132,973	143,902	155,024	162,429
Physical sciences	22,939	26,590	21,966	19,482	20,713	31,497	38,108	40,130	33,140	40,249
Math and computer sciences	6,156	5,649	5,049	5,516	8,697	8,918	17,516	12,228	19,529	7,335
Environmental sciences	8,513	8,330	6,006	4,639	4,828	4,128	8,168	15,199	13,455	18,985
Life sciences	81,732	90,452	67,319	79,357	72,685	40,315	57,823	57,954	71,203	77,031
Pyschology	2,037	1,768	1,205	1,082	1,035	871	1,739	989	2,184	1,654
Social sciences	1,616	7,149	2,213	5,277	3,209	2,493	3,618	4,834	7,985	8,178
Other sciences	3,342	1,498	1,759	1,358	633	1,786	6,001	12,568	7,528	8,997
Engineering	21,255	19,121	20,931	18,390	30,640	16,793	37,536	49,344	47,010	43,340
Non-Federal sources	642,450	792,972	838,148	956,652	1,032,206	1,115,897	1,322,994	1,543,872	1,752,592	1,885,930
Total sciences	573,753	706,601	712,083	838,207	915,962	949,092	1,046,381	1,213,431	1,434,287	1,557,445
Physical sciences	54,628	62,290	61,330	78,382	89,421	84,156	105,559	116,719	171,779	197,420
Math and computer sciences	26,767	26,255	30,602	48,690	40,224	68,291	73,087	70,423	75,883	60,183
Environmental sciences	28,214	28,460	38,000	37,535	31,390	50,446	40,777	38,864	45,221	53,687
Life sciences	370,790	500,943	511,079	588,010	643,917	650,834	710,458	851,023	978,822	1,084,821
Pyschology	15,933	9,371	11,751	15,623	30,282	11,936	16,077	8,680	9,946	12,240
Social sciences	33,340	38,553	29,131	35,621	43,732	58,227	46,301	50,373	72,724	69,305
Other sciences	44,081	40,729	30,190	34,346	36,996	25,202	54,122	77,349	79,912	79,789
Engineering	68,697	86,371	126,065	118,445	116,244	166,805	276,613	330,441	318,305	328,485

(continued)

Appendix table 5-11.
Capital expenditures at universities and colleges, by field and source of funds: 1980-89
(page 2 of 2)

Field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	Thousands of constant 1982 dollars[1]									
TOTAL	932,302	1,023,037	964,596	1,047,421	1,085,709	1,096,266	1,304,256	1,471,715	1,607,184	1,650,365
Total sciences	826,152	909,855	817,600	916,142	949,946	931,652	1,029,914	1,149,955	1,306,805	1,356,993
Physical sciences	91,534	95,359	83,296	93,890	101,795	103,694	125,462	132,885	168,494	187,522
Math and computer sciences	38,851	34,230	35,651	52,005	45,217	69,225	79,122	70,023	78,452	53,272
Environmental sciences	43,340	39,472	44,006	40,461	33,476	48,931	42,743	45,803	48,246	57,339
Life sciences	534,007	634,505	578,398	640,268	662,345	619,681	670,930	770,100	863,379	916,709
Pyschology	21,206	11,951	12,956	16,027	28,946	11,483	15,558	8,192	9,974	10,962
Social sciences	41,251	49,033	31,344	39,237	43,387	54,441	43,594	46,772	66,363	61,135
Other sciences	55,962	45,305	31,949	34,254	34,780	24,197	52,505	76,179	71,897	70,053
Engineering	106,150	113,182	146,996	131,279	135,763	164,613	274,342	321,760	300,379	293,373
Federal sources	174,166	172,261	126,448	129,615	131,655	95,757	148,903	163,721	166,122	162,353
Total sciences	149,084	151,746	105,517	111,972	103,335	80,701	116,124	121,916	127,468	128,158
Physical sciences	27,070	28,528	21,966	18,691	19,145	28,240	33,279	33,999	27,249	31,757
Math and computer sciences	7,265	6,061	5,049	5,292	8,039	7,996	15,296	10,360	16,058	5,787
Environmental sciences	10,046	8,937	6,006	4,451	4,462	3,701	7,133	12,877	11,063	14,979
Life sciences	96,449	97,046	67,319	76,135	67,182	36,146	50,496	49,100	58,546	60,778
Pyschology	2,404	1,897	1,205	1,038	957	781	1,519	838	1,796	1,305
Social sciences	1,907	7,670	2,213	5,063	2,966	2,235	3,160	4,095	6,566	6,452
Other sciences	3,944	1,607	1,759	1,303	585	1,601	5,241	10,648	6,190	7,099
Engineering	25,082	20,515	20,931	17,643	28,320	15,057	32,780	41,805	38,654	34,196
Non-Federal sources	758,136	850,776	838,148	917,806	954,054	1,000,508	1,155,353	1,307,993	1,441,062	1,488,012
Total sciences	677,068	758,109	712,083	804,171	846,611	850,952	913,791	1,028,038	1,179,337	1,228,835
Physical sciences	64,465	66,831	61,330	75,199	82,651	75,454	92,183	98,886	141,245	155,766
Math and computer sciences	31,587	28,169	30,602	46,713	37,178	61,229	63,826	59,664	62,395	47,485
Environmental sciences	33,294	30,535	38,000	36,011	29,013	45,230	35,610	32,926	37,183	42,359
Life sciences	437,558	537,459	511,079	564,133	595,164	583,535	620,434	721,001	804,833	855,931
Pyschology	18,802	10,054	11,751	14,989	27,989	10,702	14,040	7,354	8,178	9,657
Social sciences	39,344	41,363	29,131	34,175	40,421	52,206	40,434	42,677	59,797	54,682
Other sciences	52,019	43,698	30,190	32,951	34,195	22,596	47,264	65,531	65,707	62,954
Engineering	81,067	92,667	126,065	113,635	107,443	149,557	241,562	279,955	261,725	259,177

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

Science & Engineering Indicators – 1991

Appendix table 5-12.
Cost and square footage of academic R&D construction: 1986-91

Field	New R&D space			Cost[1]			Cost per square foot		
	1986-87 actual	1988-89 actual	1990-91 planned	1986-87 actual	1988-89 actual	1990-91 planned	1986-87 actual	1988-89 actual	1990-91 planned
	—Thousands of square feet—			—Millions of dollars—			—Dollars—		
Total	9,922	10,647	11,222	2,051	2,464	3,495	207	231	311
Physical sciences	799	2,000	1,564	182	401	624	228	201	399
Mathematical sciences	9	25	45	2	8	11	222	320	244
Computer sciences	237	286	392	61	65	99	257	227	253
Environmental sciences	380	324	520	57	82	165	150	253	317
Agricultural sciences	1,513	1,146	756	150	152	186	99	133	246
Biological sciences	1,708	2,262	2,808	463	577	944	271	255	336
Medical sciences	1,948	2,253	2,723	505	647	877	259	287	322
Psychology	132	115	21	23	25	9	174	217	429
Social sciences	202	329	162	38	48	34	188	146	210
Other sciences	603	418	36	139	70	17	231	167	472
Engineering	2,390	1,490	2,196	430	388	529	180	260	241

NOTE: Data for 2 years are combined, e.g., 1988-89 refers to two academic years.

[1] Project cost estimates are prorated to reflect R&D component only.

SOURCE: Science Resources Studies Division, National Science Foundation, *Scientific and Engineering Research Facilities at Universities and Colleges: 1990*, NSF 90-318 (Washington, DC: NSF, 1990).

Science & Engineering Indicators – 1991

Appendix table 5-13.

Current fund expenditures for research equipment at universities and colleges, by field: 1981-89

(page 1 of 2)

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989
Federal and non-Federal									
	Thousands of current dollars								
Total	418,273	421,400	455,167	541,596	680,508	790,166	847,339	921,099	997,880
Physical sciences	77,527	79,554	81,039	103,684	142,045	163,010	165,492	180,910	179,388
Mathematical sciences	2,641	3,568	3,746	5,326	6,149	6,854	9,764	9,601	10,555
Computer sciences	13,011	14,726	18,588	22,919	37,541	44,274	43,645	44,505	42,321
Environmental sciences	31,102	28,528	31,672	41,625	48,280	51,846	55,532	55,563	66,430
Life sciences	199,646	201,924	211,370	245,998	287,553	335,407	344,107	386,374	442,421
Pyschology	5,754	5,701	6,603	7,346	8,758	8,673	10,600	9,647	10,717
Social sciences	7,793	7,073	9,452	13,800	10,040	13,892	11,779	11,832	14,378
Other sciences	7,261	8,992	10,438	10,342	14,718	20,070	27,265	27,005	26,680
Engineering	73,538	71,334	82,259	90,556	125,424	146,140	179,155	195,662	204,990
Federal									
Total	262,394	270,433	281,267	342,321	433,132	501,902	527,230	577,412	594,191
Physical sciences	59,460	63,763	63,610	82,653	113,189	130,405	130,267	142,077	131,653
Mathematical sciences	1,850	2,559	2,485	4,082	4,934	5,172	7,577	7,516	6,946
Computer sciences	7,132	9,865	12,223	16,846	29,398	35,098	33,932	34,716	28,983
Environmental sciences	18,870	18,370	19,719	29,760	33,041	35,779	36,144	36,624	44,790
Life sciences	117,842	116,473	115,033	137,224	157,056	188,614	188,344	215,754	239,523
Psychology	4,166	4,052	4,596	4,998	6,228	5,857	8,105	6,575	6,892
Social sciences	3,380	2,748	3,103	3,905	4,044	4,179	3,438	3,296	4,672
Other sciences	4,061	5,724	6,245	5,601	6,792	11,762	14,085	13,014	13,410
Engineering	45,633	46,879	54,253	57,252	78,450	85,036	105,338	117,840	117,322
Non-Federal									
Total	155,879	150,967	173,900	199,275	247,376	288,264	320,109	343,687	403,689
Physical sciences	18,067	15,791	17,429	21,031	28,856	32,605	35,225	38,833	47,735
Mathematical sciences	791	1,009	1,261	1,244	1,215	1,682	2,187	2,085	3,609
Computer sciences	5,879	4,861	6,365	6,073	8,143	9,176	9,713	9,789	13,338
Environmental sciences	12,232	10,158	11,953	11,865	15,239	16,067	19,388	18,939	21,640
Life sciences	81,804	85,451	96,337	108,774	130,497	146,793	155,763	170,620	202,898
Pyschology	1,588	1,649	2,007	2,348	2,530	2,816	2,495	3,072	3,825
Social sciences	4,413	4,325	6,349	9,895	5,996	9,713	8,341	8,536	9,706
Other sciences	3,200	3,268	4,193	4,741	7,926	8,308	13,180	13,991	13,270
Engineering	27,905	24,455	28,006	33,304	46,974	61,104	73,817	77,822	87,668
Federal and non-Federal									
	Thousands of constant 1982 dollars[1]								
Total	448,763	421,400	436,684	500,590	610,140	690,042	717,879	757,370	787,334
Physical sciences	83,178	79,554	77,748	95,834	127,357	142,354	140,208	148,753	141,538
Mathematical sciences	2,834	3,568	3,594	4,923	5,513	5,986	8,272	7,894	8,328
Computer sciences	13,959	14,726	17,833	21,184	33,659	38,664	36,977	36,594	33,392
Environmental sciences	33,369	28,528	30,386	38,473	43,288	45,276	47,048	45,686	52,414
Life sciences	214,199	201,924	202,787	227,373	257,819	292,906	291,533	317,695	349,073
Pyschology	6,173	5,701	6,335	6,790	7,852	7,574	8,980	7,932	8,456
Social sciences	8,361	7,073	9,068	12,755	9,002	12,132	9,979	9,729	11,344
Other sciences	7,790	8,992	10,014	9,559	13,196	17,527	23,099	22,205	21,051
Engineering	78,899	71,334	78,919	83,700	112,455	127,622	151,783	160,882	161,739

(continued)

Appendix table 5-13.

Current fund expenditures for research equipment at universities and colleges, by field: 1981-89

(page 2 of 2)

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989
Federal									
	Thousands of constant 1982 dollars[1]								
Total	281,521	270,433	269,846	316,403	388,344	438,304	446,678	474,775	468,821
Physical sciences	63,794	63,763	61,027	76,395	101,485	113,881	110,364	116,822	103,875
Mathematical sciences	1,985	2,559	2,384	3,773	4,424	4,517	6,419	6,180	5,480
Computer sciences	7,652	9,865	11,727	15,571	26,358	30,651	28,748	28,545	22,868
Environmental sciences	20,246	18,370	18,918	27,507	29,624	31,245	30,622	30,114	35,340
Life sciences	126,432	116,473	110,362	126,834	140,816	164,714	159,568	177,403	188,985
Pyschology	4,470	4,052	4,409	4,620	5,584	5,115	6,867	5,406	5,438
Social sciences	3,626	2,748	2,977	3,609	3,626	3,649	2,913	2,710	3,686
Other sciences	4,357	5,724	5,991	5,177	6,090	10,272	11,933	10,701	10,581
Engineering	48,959	46,879	52,050	52,917	70,338	74,261	89,244	96,894	92,568
Non-Federal									
Total	167,242	150,967	166,839	184,187	221,796	251,737	271,202	282,595	318,513
Physical sciences	19,384	15,791	16,721	19,439	25,872	28,474	29,843	31,930	37,663
Mathematical sciences	849	1,009	1,210	1,150	1,089	1,469	1,853	1,714	2,848
Computer sciences	6,308	4,861	6,107	5,613	7,301	8,013	8,229	8,049	10,524
Environmental sciences	13,124	10,158	11,468	10,967	13,663	14,031	16,426	15,573	17,074
Life sciences	87,767	85,451	92,425	100,538	117,003	128,192	131,965	140,292	160,088
Psychology	1,704	1,649	1,926	2,170	2,268	2,459	2,114	2,526	3,018
Social sciences	4,735	4,325	6,091	9,146	5,376	8,482	7,067	7,019	7,658
Other sciences	3,433	3,268	4,023	4,382	7,106	7,255	11,166	11,504	10,470
Engineering	29,939	24,455	26,869	30,782	42,117	53,361	62,539	63,989	69,171

[1] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars into constant 1982 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and annual series.

Science & Engineering Indicators – 1991

Appendix table 5-14.

Trends in research equipment in the $10,000-$999,000 range, by system age: 1982-83, 1985-86, and 1988-89

	1982-83		1985-86		1988-89	
	Number	Percent	Number	Percent	Number	Percent
Total systems	36,300	100	53,390	100	78,950	100
Age (from year of purchase)						
Less than 3 years	12,705	35	19,637	37	29,968	38
3-5 years	9,801	27	13,791	26	24,312	31
6 or more years	13,794	38	19,962	37	24,670	31

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Science/Engineering Equipment in Academic Settings: 1989-90,* NSF 91-315 (Washington, DC: NSF, 1991); and earlier reports.

Science & Engineering Indicators – 1991

Appendix table 5-15.

National stock of in-use academic instrumentation, in selected fields: 1982-83, 1985-86, and 1988-89

	Instrument systems			Aggregate purchase price			Mean price per system		
Field	1982-83	1985-86	1988-89	1982-83	1985-86	1988-89	1982-83	1985-86	1988-89
	Number			Millions of dollars			Thousands of dollars		
Total	36,300	53,390	78,950	1,303	2,044	3,177	36.1	38.3	40.2
Chemistry	4,800	7,019	10,365	210	340	551	43.6	48.5	53.2
Physics/astronomy	3,900	5,325	8,131	180	248	357	45.8	46.6	44.0
Computer sciences	900	2,178	3,703	50	109	165	57.8	49.8	44.4
Environmental sciences	2,100	3,300	4,477	109	172	246	51.6	52.2	55.0
Biological sciences	15,300	22,301	29,530	420	645	928	27.4	28.9	31.4
Agricultural sciences	1,600	2,570	3,851	38	62	93	22.7	24.2	24.2
Engineering	7,600	10,697	18,894	296	467	837	38.5	43.7	44.3

NOTES: Details may not sum to totals because of rounding. Number of instrument systems, aggregate purchase price, and mean price per system are not adjusted for inflation.

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Science/Engineering Equipment in Academic Settings: 1989-90,* NSF 91-315 (Washington, DC: NSF, 1991); and earlier reports.

Science & Engineering Indicators – 1991

Appendix table 5-16.

Number and percentage of science and engineering fields in 277 universities and colleges, by total R&D volume and field: 1980-89

(page 1 of 2)

	Total	More than $1 million	More than $5 million	More than $10 million	Total	More than $1 million	More than $5 million	More than $10 million
Total science and engineering								
	Number				Percent			
1980	3,621	1,162	382	188	52.3	16.8	5.5	2.7
1981	3,530	1,186	377	197	51.0	17.1	5.4	2.8
1982	3,539	1,192	372	195	51.1	17.2	5.4	2.8
1983	3,546	1,225	394	209	51.2	17.7	5.7	3.0
1984	3,601	1,231	402	222	52.0	17.8	5.8	3.2
1985	3,602	1,308	441	247	52.0	18.9	6.4	3.6
1986	3,691	1,396	482	264	53.3	20.2	7.0	3.8
1987	3,672	1,450	512	291	53.0	20.9	7.4	4.2
1988	3,670	1,526	543	301	53.0	22.0	7.8	4.3
1989	3,717	1,575	572	310	53.7	22.7	8.3	4.5
Physical sciences								
1980	542	203	49	9	48.9	18.3	4.4	0.8
1981	531	207	47	8	47.9	18.7	4.2	0.7
1982	532	209	50	8	48.0	18.9	4.5	0.7
1983	536	218	53	11	48.4	19.7	4.8	1.0
1984	538	223	55	13	48.6	20.1	5.0	1.2
1985	541	236	70	16	48.8	21.3	6.3	1.4
1986	551	249	78	17	49.7	22.5	7.0	1.5
1987	556	256	79	21	50.2	23.1	7.1	1.9
1988	547	269	86	23	49.4	24.3	7.8	2.1
1989	558	274	90	25	50.4	24.7	8.1	2.3
Mathematical and computer sciences								
1980	316	51	9	1	57.0	9.2	1.6	0.2
1981	323	55	8	2	58.3	9.9	1.4	0.4
1982	333	56	8	1	60.1	10.1	1.4	0.2
1983	335	67	9	2	60.5	12.1	1.6	0.4
1984	344	69	11	5	62.1	12.5	2.0	0.9
1985	344	76	15	7	62.1	13.7	2.7	1.3
1986	364	90	16	8	65.7	16.2	2.9	1.4
1987	365	101	17	9	65.9	18.2	3.1	1.6
1988	369	109	22	10	66.6	19.7	4.0	1.8
1989	379	114	23	8	68.4	20.6	4.2	1.4
Environmental sciences								
1980	446	132	33	11	40.3	11.9	3.0	1.0
1981	395	142	31	11	35.6	12.8	2.8	1.0
1982	385	138	30	11	34.7	12.5	2.7	1.0
1983	370	138	30	11	33.4	12.5	2.7	1.0
1984	367	136	29	13	33.1	12.3	2.6	1.2
1985	364	140	33	16	32.9	12.6	3.0	1.4
1986	380	143	38	18	34.3	12.9	3.4	1.6
1987	380	149	38	20	34.3	13.4	3.4	1.8
1988	380	146	41	19	34.3	13.2	3.7	1.7
1989	372	155	46	18	33.6	14.0	4.2	1.6
Life sciences								
1980	593	360	227	145	53.5	32.5	20.5	13.1
1981	600	366	231	156	54.2	33.0	20.8	14.1
1982	610	370	229	151	55.1	33.4	20.7	13.6
1983	628	379	242	165	56.7	34.2	21.8	14.9
1984	640	380	239	170	57.8	34.3	21.6	15.3
1985	642	387	249	185	57.9	34.9	22.5	16.7
1986	658	393	261	192	59.4	35.5	23.6	17.3
1987	657	404	268	201	59.3	36.5	24.2	18.1
1988	652	415	269	208	58.8	37.5	24.3	18.8
1989	660	420	278	213	59.6	37.9	25.1	19.2

(continued)

Appendix table 5-16.

Number and percentage of science and engineering fields in 277 universities and colleges, by total R&D volume and field: 1980-89

(page 2 of 2)

	Total	More than $1 million	More than $5 million	More than $10 million	Total	More than $1 million	More than $5 million	More than $10 million
Social sciences and psychology								
	Number				Percent			
1980	868	165	17	3	62.7	11.9	1.2	0.2
1981	859	166	14	3	62.0	12.0	1.0	0.2
1982	879	160	12	2	63.5	11.6	0.9	0.1
1983	871	151	13	1	62.9	10.9	0.9	0.1
1984	906	145	17	2	65.4	10.5	1.2	0.1
1985	889	158	15	1	64.2	11.4	1.1	0.1
1986	908	181	22	1	65.6	13.1	1.6	0.1
1987	890	184	23	4	64.3	13.3	1.7	0.3
1988	896	203	28	4	64.7	14.7	2.0	0.3
1989	907	214	30	6	65.5	15.5	2.2	0.4
Engineering								
1980	856	251	47	19	51.5	15.1	2.8	1.1
1981	822	250	46	17	49.5	15.0	2.8	1.0
1982	800	259	43	22	48.1	15.6	2.6	1.3
1983	806	272	47	19	48.5	16.4	2.8	1.1
1984	806	278	51	19	48.5	16.7	3.1	1.1
1985	822	311	59	22	49.5	18.7	3.5	1.3
1986	830	340	67	28	49.9	20.5	4.0	1.7
1987	824	356	87	36	49.6	21.4	5.2	2.2
1988	826	384	97	37	49.7	23.1	5.8	2.2
1989	841	398	105	40	50.6	23.9	6.3	2.4

NOTES: Data represent 26 fields in 277 universities and colleges continuously surveyed by the National Science Foundation since 1973. Funding is in constant 1988 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

Science & Engineering Indicators – 1991

Appendix table 5-17.

Selected academic institutions by number of their science and engineering fields exceeding $1 million in total R&D expenditures: 1980-89

Number of fields	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	75	70	73	74	73	62	57	52	49	47
1	30	32	29	25	28	35	31	30	25	30
2	39	38	42	38	37	43	40	38	41	37
3	17	18	15	18	15	10	16	22	22	21
4	15	12	14	17	14	13	16	18	21	15
5	13	22	16	16	20	17	12	12	11	16
6	13	11	14	16	16	16	15	12	14	10
7	10	9	10	7	12	13	15	14	12	12
8	11	8	9	11	5	7	11	9	7	12
9	8	9	5	5	9	8	8	12	7	8
10	9	10	12	12	7	7	8	7	12	10
11	6	7	8	5	8	8	7	9	8	9
12	7	9	4	6	7	6	8	5	8	6
13	6	4	6	5	6	8	6	8	6	11
14	3	5	5	4	3	5	3	5	7	5
15	7	4	4	5	6	4	7	4	3	4
16	2	1	2	3	1	4	2	3	3	2
17	0	3	2	3	2	3	3	4	6	4
18	2	1	1	1	0	0	2	4	5	6
19	1	0	4	1	2	1	3	0	0	2
20	2	3	1	4	4	3	3	4	4	3
21	1	0	0	0	0	2	2	3	3	4
22	0	1	1	0	1	1	0	0	1	1
23	0	0	0	1	1	1	1	1	1	2
24	0	0	0	0	0	0	1	1	1	0
25	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0

NOTES: Data represent 26 fields in 277 universities and colleges continuously surveyed by the National Science Foundation since 1973. Funding is in constant 1988 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-6.

Science & Engineering Indicators – 1991

Appendix table 5-18.
Total and Federal academic R&D funds, by geographic region and field: 1973-74, 1980-81, and 1988-89

Region	Total science and engineering	Physical sciences	Mathematical and computer sciences	Environ-mental sciences	Life sciences	Psychology	Social sciences	Other sciences	Engineering
					1973-74				
				Percentage of total R&D					
East	28.0	33.2	36.3	26.1	27.0	28.8	27.5	26.3	27.4
West	24.3	27.6	20.6	43.7	22.1	21.6	20.9	14.0	24.8
North	24.1	21.0	23.0	14.9	23.7	29.6	31.5	31.9	26.4
South	23.3	18.2	20.0	15.0	26.5	20.0	20.0	27.7	21.2
					1980-81				
East	26.5	31.8	37.9	24.5	24.9	31.2	26.7	18.9	27.8
West	24.8	27.5	16.0	41.3	22.8	21.9	20.5	24.4	24.4
North	22.7	21.0	21.2	13.1	23.7	29.8	28.3	30.3	21.8
South	25.7	19.7	24.8	20.8	28.0	17.1	24.2	26.4	25.9
					1988-89				
East	26.0	27.7	36.9	24.0	24.8	32.4	28.0	15.8	27.3
West	23.1	28.6	22.3	35.7	21.6	22.4	17.6	17.1	21.5
North	21.1	19.9	15.2	11.9	22.1	22.5	23.5	36.8	21.2
South	29.1	23.0	24.9	27.4	30.7	21.2	29.9	30.1	29.5
					1973-74				
				Percentage of Federal R&D					
East	29.9	34.2	41.4	28.4	29.1	28.4	26.6	29.6	28.9
West	26.7	29.2	21.8	48.7	24.0	23.2	22.5	13.0	27.9
North	22.2	20.9	21.7	10.4	21.6	27.8	33.0	29.8	25.2
South	21.0	15.7	15.1	12.4	24.9	20.6	17.9	27.6	17.9
					1980-81				
East	29.2	32.7	40.6	27.3	28.1	30.1	29.5	18.0	30.2
West	26.7	29.4	19.2	44.2	23.7	23.7	21.1	27.1	28.4
North	21.0	21.2	20.9	10.9	21.5	30.5	28.5	26.5	20.7
South	22.8	16.6	19.1	17.4	26.2	15.7	20.9	28.4	20.7
					1988-89				
East	28.6	29.6	40.2	26.7	28.1	32.5	27.8	13.0	28.4
West	25.7	30.7	27.5	38.5	22.7	25.4	19.1	22.2	27.1
North	19.6	19.8	13.0	10.1	20.5	22.3	26.8	29.7	19.9
South	25.5	19.2	18.7	23.4	28.1	18.0	25.7	34.9	24.1

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See text table 5-4.

Science & Engineering Indicators – 1991

Appendix table 5-19.
Total and Federal academic R&D funds, by state: 1973-74, 1980-81, and 1988-89

	Total R&D funds			Federal R&D funds		
State	1973-74	1980-81	1988-89	1973-74	1980-81	1988-89
TOTAL U.S.	6,957,428	8,516,040	13,534,597	4,734,782	5,640,293	8,013,164
Alabama	68,264	86,948	201,203	48,959	57,101	117,105
Alaska	41,929	53,634	52,133	26,634	31,199	24,511
Arizona	72,454	114,176	206,839	37,550	62,856	97,870
Arkansas	25,241	41,160	41,727	10,838	12,736	15,126
California	909,923	1,133,468	1,771,457	729,244	853,894	1,225,363
Colorado	149,326	174,311	211,870	115,011	130,202	156,176
Connecticut	127,378	174,674	265,068	93,220	136,424	177,226
Delaware	13,380	23,044	34,350	7,370	12,622	15,492
District of Columbia	71,689	75,789	106,217	57,006	54,553	78,285
Florida	176,897	204,349	336,286	98,970	111,109	172,155
Georgia	130,967	197,320	383,293	58,904	103,286	188,953
Hawaii	54,416	56,702	66,077	34,789	34,653	38,747
Idaho	22,693	24,255	31,320	10,178	11,328	11,636
Illinois	324,353	344,751	565,177	234,023	241,156	320,937
Indiana	132,574	151,017	215,068	94,483	100,698	130,711
Iowa	89,881	134,477	191,534	49,659	71,347	93,586
Kansas	76,003	71,067	101,787	47,837	37,409	42,500
Kentucky	40,057	55,594	88,364	21,194	25,278	34,187
Louisiana	83,460	112,037	173,385	35,619	44,740	65,951
Maine	16,253	22,169	18,436	10,597	9,295	7,572
Maryland	176,314	209,527	453,681	136,676	164,623	267,580
Massachusetts	460,890	563,641	818,277	378,669	452,787	594,032
Michigan	260,123	307,132	453,699	163,988	179,261	247,986
Minnesota	136,158	171,339	243,299	78,625	99,362	124,368
Mississippi	48,217	59,223	73,903	21,677	23,278	33,528
Missouri	156,664	160,898	241,836	99,653	100,900	130,888
Montana	22,865	26,295	32,148	9,915	14,136	12,612
Nebraska	45,867	61,115	86,742	17,663	23,262	35,219
Nevada	16,435	17,621	36,400	7,817	9,121	19,827
New Hampshire	18,998	31,776	58,659	15,646	22,865	39,602
New Jersey	121,951	123,181	258,633	68,884	74,978	110,167
New Mexico	40,846	85,343	130,054	32,564	65,279	73,893
New York	817,816	856,638	1,274,185	576,985	600,764	839,956
North Carolina	182,093	197,632	400,220	127,821	137,355	247,718
North Dakota	16,710	26,850	25,481	6,632	10,310	17,448
Ohio	187,587	261,372	392,104	127,200	170,328	225,555
Oklahoma	46,190	78,259	112,532	24,776	31,672	32,502
Oregon	84,008	103,193	152,439	58,250	63,960	92,996
Pennsylvania	333,071	405,658	706,119	229,245	287,630	440,510
Rhode Island	32,363	51,516	77,060	28,696	44,406	56,141
South Carolina	29,351	50,064	109,967	13,155	26,148	40,905
South Dakota	15,987	14,007	12,243	7,090	5,999	5,955
Tennessee	82,108	122,175	200,092	65,736	73,492	111,979
Texas	342,309	524,414	937,620	203,405	307,776	468,579
Utah	89,001	95,319	152,099	65,878	68,623	101,227
Vermont	17,827	23,507	39,202	11,758	16,970	26,553
Virginia	87,632	126,168	246,478	52,858	88,398	135,571
Washington	167,376	206,872	256,550	124,975	150,988	190,202
West Virginia	16,454	25,413	34,137	10,902	13,751	16,323
Wisconsin	232,321	232,185	333,245	123,646	145,305	193,489
Wyoming	16,288	16,577	21,399	10,792	8,866	12,191
Remaining areas	28,465	30,187	102,506	11,118	15,811	53,574

NOTE: Funding is in constant 1988 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Academic Science/Engineering: R&D Expenditures, Fiscal Year 1989*, NSF 90-321, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-7.

Science & Engineering Indicators – 1991

Appendix table 5-20.

Science and engineering doctorate-holders employed by academic institutions and those active in R&D, by field: 1979 and 1989

Field	Total employment		Total in R&D		Active in R&D	
	1979	1989	1979	1989	1979	1989
	Number				Percent	
TOTAL SCIENCE AND ENGINEERING	153,220	202,089	100,562	154,860	65.6	76.6
Physical sciences	22,549	25,163	15,513	19,800	68.8	78.7
Astronomy	1,235	1,642	1,074	1,486	87.0	90.5
Chemistry	13,147	14,276	8,460	10,849	64.3	76.0
Physics	8,167	9,245	5,979	7,465	73.2	80.7
Math and computer sciences	13,504	19,118	8,235	13,465	61.0	70.4
Mathematical sciences	11,001	12,323	6,560	8,825	59.6	71.6
Computer sciences	2,192	6,090	1,491	4,122	68.0	67.7
Other	311	705	184	518	59.2	73.5
Environmental sciences	5,278	7,385	4,106	6,560	77.8	88.8
Atmospheric sciences	637	845	615	800	96.5	94.7
Earth sciences	3,454	4,493	2,554	3,870	73.9	86.1
Oceanography	669	1,328	645	1,261	94.9	95.0
Other	518	719	292	629	57.8	87.5
Life sciences	48,282	67,380	36,353	55,647	75.3	82.6
Agricultural sciences	6,567	8,943	4,993	7,696	76.0	86.1
Biological sciences	32,936	45,569	25,982	39,380	78.9	86.4
Medical sciences	7,232	9,202	4,796	6,452	66.3	70.1
Other	1,547	3,666	582	2,119	37.6	57.8
Psychology	16,616	21,354	8,112	12,423	48.8	58.2
Social sciences	28,165	37,158	15,021	27,294	53.3	73.5
Anthropology	2,044	2,763	1,070	2,205	52.3	79.8
Economics	7,126	10,497	4,711	8,052	66.1	76.7
History of science	350	1,077	172	576	57.3	53.5
Linguistics	969	1,430	667	1,194	68.8	83.5
Political science	7,842	9,278	3,064	6,678	38.8	72.0
Sociology	5,655	6,949	3,268	4,967	57.8	71.5
Other	4,179	5,164	2,069	3,622	49.5	70.1
Other sciences	5,052	3,133	2,628	1,922	52.0	61.3
Engineering	13,839	21,517	10,659	17,749	77.0	82.5
Aeronautical/astronautical	598	1,031	556	893	93.0	86.6
Chemical	1,060	2,051	777	1,886	73.3	92.0
Civil	2,165	3,278	1,822	2,529	84.2	77.2
Electrical/electronic	2,490	4,402	1,830	3,442	73.5	78.2
Materials/metallurgy	1,300	1,595	1,044	1,421	80.3	89.1
Mechanical	2,374	3,938	1,675	3,295	70.6	83.4
Other	3,852	5,222	2,955	4,283	76.7	82.2

NOTE: Academic institutions exclude federally funded research and development centers.

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-8.

Science & Engineering Indicators – 1991

Appendix table 5-21.

Academic employment and R&D activity of doctoral scientists and engineers, by gender, race/ethnicity, and field: 1979 and 1989

(page 1 of 2)

	1979					1989				
	White	Black	Asian	Native American	Hispanic	White	Black	Asian	Native American	Hispanic
					Total					
Total employed										
Total science and engineering	138,162	1,721	9,966	267	2,019	177,232	3,299	16,420	387	3,893
Physical sciences	20,085	130	1,801	43	349	21,780	363	2,188	70	526
Math and computer sciences	12,054	128	998	*	207	16,390	169	1,998	32	428
Environmental sciences	4,991	*	176	*	71	6,774	24	383	*	193
Life sciences	43,310	523	3,507	46	627	59,576	927	5,537	80	1,095
Psychology	15,885	284	194	38	67	19,920	531	418	44	258
Social sciences	25,511	542	1,479	90	312	32,900	987	2,147	143	837
Other sciences	4,512	78	306	32	64	2,477	141	359	*	87
Engineering	11,814	35	1,505	*	322	17,415	157	3,390	*	469
Active in R&D										
Total science and engineering	89,395	866	8,173	206	1,257	133,976	2,055	14,627	302	3,154
Physical sciences	13,633	94	1,478	*	183	16,923	306	1,913	68	432
Math and computer sciences	7,199	51	751	*	131	11,264	115	1,636	28	321
Environmental sciences	3,856	*	160	*	56	6,016	22	337	*	174
Life sciences	32,117	340	3,151	46	520	48,732	659	5,042	66	1,005
Psychology	7,804	94	68	38	30	11,650	217	290	33	85
Social sciences	13,651	251	822	59	171	24,016	540	1,820	89	703
Other sciences	2,242	22	269	32	33	1,447	84	319	*	70
Engineering	8,893	*	1,474	*	133	13,928	112	3,270	*	364
					Men					
Total employed										
Total science and engineering	121,089	1,296	8,688	251	1,739	145,304	2,228	13,823	315	3,066
Physical sciences	18,811	119	1,600	43	332	19,861	333	1,831	70	441
Math and computer sciences	11,229	117	890	*	201	14,768	140	1,755	30	397
Environmental sciences	4,711	*	163	*	66	6,123	22	354	*	180
Life sciences	36,562	324	2,810	35	530	45,647	524	4,175	47	805
Psychology	12,429	207	134	34	*	13,533	249	228	30	93
Social sciences	21,779	447	1,359	90	241	26,443	696	1,875	124	628
Other sciences	3,866	47	257	32	36	1,993	114	305	*	76
Engineering	11,702	34	1,475	*	322	16,936	150	3,300	*	446

(continued)

Appendix table 5-21.

Academic employment and R&D activity of doctoral scientists and engineers, by gender, race/ethnicity, and field: 1979 and 1989

(page 2 of 2)

	1979					1989				
	White	Black	Asian	Native American	Hispanic	White	Black	Asian	Native American	Hispanic
Men										
Active in R&D										
Total science and engineering	79,634	654	7,184	191	1,101	110,934	1,413	12,362	251	2,496
Physical sciences	12,917	89	1,329	*	174	15,555	278	1,609	68	361
Math and computer sciences	6,782	50	691	*	127	10,259	99	1,442	26	297
Environmental sciences	3,663	*	147	*	54	5,426	22	308	*	164
Life sciences	27,367	225	2,554	35	454	37,720	404	3,770	37	752
Psychology	6,221	60	40	34	*	8,041	80	153	30	*
Social sciences	11,844	208	749	59	134	19,248	348	1,620	76	517
Other sciences	2,041	*	228	32	25	1,192	75	273	*	61
Engineering	8,799	*	1,446	*	133	13,493	107	3,187	*	344
Women										
Total employed										
Total science and engineering	17,073	425	1,278	*	280	31,928	1,071	2,597	72	827
Physical sciences	1,274	*	201	*	17	1,919	30	357	*	85
Math and computer sciences	825	*	108	*	6	1,622	29	243	*	31
Environmental sciences	280	*	*	*	5	651	*	29	*	*
Life sciences	6,748	199	697	*	97	13,929	403	1,362	33	290
Psychology	3,456	77	60	*	56	6,387	282	190	*	165
Social sciences	3,732	95	120	*	71	6,457	291	272	*	209
Other sciences	646	31	49	*	28	484	27	54	*	*
Engineering	112	*	30	*	0	479	*	90	*	23
Active in R&D										
Total science and engineering	9,761	212	989	*	156	23,042	642	2,265	51	658
Physical sciences	716	*	149	*	*	1,368	28	304	*	71
Math and computer sciences	417	*	60	*	*	1,005	*	194	*	24
Environmental sciences	193	*	*	*	*	590	*	29	*	*
Life sciences	4,750	115	597	*	66	11,012	255	1,272	29	253
Psychology	1,583	34	28	*	30	3,609	137	137	*	85
Social sciences	1,807	43	73	*	37	4,768	192	200	*	186
Other sciences	201	*	41	*	*	255	*	46	*	*
Engineering	94	*	28	*	*	435	*	83	*	20

* = too few cases to estimate

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-9 and text tables 5-5 and 5-6.

Science & Engineering Indicators – 1991

Appendix table 5-22.

Academic doctoral scientists and engineers active in R&D, by number of years since Ph.D. award and field: 1973-89

(page 1 of 2)

	1-3 years	4-7 years	8-10 years	11-15 years	More than 15 years
Total science and engineering					
	Percent				
1973	20.7	26.0	13.9	14.2	25.3
1975	17.8	26.3	14.8	15.8	25.2
1977	15.4	23.9	15.7	17.5	27.6
1979	14.8	21.1	15.4	20.1	28.5
1981	14.4	19.7	13.9	20.6	31.4
1983	13.3	17.7	12.0	22.3	34.7
1985	12.8	16.9	11.8	19.4	39.1
1987	11.6	16.2	10.8	17.9	43.5
1989	12.3	15.7	10.4	16.6	45.0
Physical sciences					
1973	18.2	25.5	14.8	16.0	25.4
1975	13.4	23.5	16.4	18.5	28.2
1977	13.7	19.6	16.1	18.7	31.9
1979	12.8	15.6	14.0	23.9	33.6
1981	13.8	14.9	10.7	22.0	38.6
1983	10.5	11.9	9.3	21.4	46.8
1985	11.8	12.2	8.5	14.4	53.0
1987	11.1	11.3	7.2	13.9	56.5
1989	13.8	12.5	7.3	11.1	55.3
Mathematical and computer sciences					
1973	22.9	30.9	15.3	12.2	18.7
1975	17.5	30.8	15.8	16.3	19.6
1977	15.4	24.5	19.1	17.6	23.5
1979	13.3	18.9	18.7	24.4	24.6
1981	13.8	18.6	13.8	24.7	29.2
1983	12.6	18.7	10.3	23.0	35.5
1985	12.7	17.3	8.8	20.3	40.9
1987	11.0	17.3	9.3	17.0	45.3
1989	12.0	16.5	9.8	14.6	47.2
Environmental sciences					
1973	21.4	25.0	14.3	15.0	24.3
1975	21.3	24.1	16.0	15.8	22.8
1977	16.5	25.5	13.4	17.5	27.0
1979	15.8	18.9	15.4	21.9	28.0
1981	17.6	17.4	14.8	19.1	31.1
1983	14.9	19.7	14.0	17.8	33.6
1985	11.0	17.4	12.1	20.1	39.3
1987	12.7	17.2	7.5	21.7	40.9
1989	10.3	17.1	10.0	17.7	45.0
Life sciences					
1973	19.6	23.8	12.5	13.7	30.4
1975	17.8	25.8	13.1	15.1	28.3
1977	15.6	24.3	15.0	16.2	28.9
1979	15.4	23.0	15.2	17.4	29.1
1981	15.9	20.7	13.7	19.6	30.2
1983	14.5	18.0	12.4	22.5	32.7
1985	13.6	18.2	11.8	20.8	35.6
1987	12.4	17.4	12.1	18.6	39.4
1989	13.7	17.0	11.5	16.9	40.9

(continued)

Appendix table 5-22.

Academic doctoral scientists and engineers active in R&D, by number of years since Ph.D. award and field: 1973-89

(page 2 of 2)

	1-3 years	4-7 years	8-10 years	11-15 years	More than 15 years
			Social sciences and psychology		
			Percent		
1973	24.6	25.7	12.8	13.6	23.2
1975	22.3	28.4	13.4	13.4	22.6
1977	17.4	28.1	14.8	15.1	24.7
1979	18.1	24.8	16.8	17.2	23.2
1981	14.5	24.1	15.4	19.9	26.0
1983	13.2	21.1	15.3	21.0	29.4
1985	11.8	18.1	15.8	21.2	33.1
1987	10.5	16.3	13.1	20.7	39.4
1989	9.7	15.4	11.3	20.3	43.3
			Engineering		
1973	17.7	30.4	17.3	15.3	19.4
1975	13.2	24.7	20.1	19.6	22.4
1977	12.8	18.2	17.6	25.6	25.8
1979	11.4	18.6	11.6	25.8	32.5
1981	11.7	16.2	14.3	20.3	37.5
1983	14.1	16.0	7.9	26.2	35.8
1985	14.5	15.9	9.9	16.1	43.6
1987	12.3	16.9	8.4	14.0	48.4
1989	13.5	15.4	9.5	14.3	47.2

NOTE: "Active in R&D" is defined as those individuals who report R&D as either their primary or secondary activity.

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-10.

Science & Engineering Indicators – 1991

Appendix table 5-23.

Participation of academic doctoral scientists and engineers in R&D, by number of years since Ph.D. award and field: 1973-89

(page 1 of 2)

	Total	1-3 years	4-7 years	8-10 years	11-15 years	More than 15 years
Total science and engineering						
	Percent					
1973	77.9	80.9	79.7	79.1	76.0	74.2
1975	73.2	80.2	75.3	73.8	71.1	68.0
1977	68.2	73.2	68.3	69.0	66.1	66.5
1979	66.5	76.3	68.7	64.9	64.8	62.8
1981	64.6	80.3	70.6	63.4	60.0	59.7
1983	63.1	77.7	72.1	64.0	59.8	57.2
1985	64.3	77.8	71.5	67.7	59.8	59.6
1987	76.5	87.2	83.2	80.0	75.3	71.6
1989	77.7	88.6	87.2	80.4	77.4	72.0
Physical sciences						
1973	80.7	84.6	81.7	83.9	82.2	74.7
1975	77.4	85.3	79.7	80.3	76.3	71.9
1977	74.1	87.8	73.2	73.3	70.5	72.4
1979	69.1	89.1	75.4	66.5	67.4	63.5
1981	68.7	92.0	83.5	70.6	62.0	62.2
1983	69.7	89.1	81.6	74.8	66.3	64.7
1985	69.3	90.9	84.7	78.5	60.2	64.6
1987	78.6	94.8	89.2	87.6	79.0	73.4
1989	79.5	96.4	94.5	89.6	78.8	72.7
Mathematical and computer sciences						
1973	73.6	75.6	75.8	79.0	72.5	65.1
1975	69.5	75.2	69.6	69.4	73.2	62.5
1977	63.7	71.9	61.8	64.5	59.6	63.6
1979	61.1	81.6	58.2	58.0	60.5	58.4
1981	58.2	79.1	65.7	52.6	52.8	54.7
1983	59.9	75.3	71.4	53.7	53.6	57.2
1985	56.7	73.4	71.2	53.8	48.7	53.3
1987	70.4	89.6	84.7	71.9	65.5	64.4
1989	72.0	89.0	88.4	81.3	68.1	64.4
Environmental sciences						
1973	82.3	89.6	80.1	84.6	85.6	76.0
1975	80.5	94.7	85.3	79.0	74.4	71.3
1977	80.6	93.4	84.5	76.7	72.9	78.0
1979	78.4	88.8	81.8	75.5	77.6	73.5
1981	75.5	97.8	85.1	69.0	69.1	69.2
1983	76.7	89.3	87.4	85.9	68.6	68.6
1985	77.5	87.0	84.9	85.8	75.3	71.5
1987	89.6	91.1	98.0	82.5	91.7	86.5
1989	89.7	96.4	95.5	91.9	92.0	85.1
Life sciences						
1973	84.5	84.8	87.6	84.5	82.5	82.9
1975	80.0	83.9	81.8	81.9	79.3	75.8
1977	77.5	79.8	78.6	79.1	76.8	75.2
1979	76.4	84.6	78.5	76.1	74.7	72.3
1981	75.8	89.2	81.2	74.3	73.8	69.1
1983	75.1	86.2	80.8	77.4	73.1	68.9
1985	74.1	87.6	81.1	74.3	72.7	67.8
1987	83.1	90.4	86.9	88.0	82.8	78.4
1989	83.3	89.7	89.6	84.0	84.2	78.6

(continued)

Appendix table 5-23.

Participation of academic doctoral scientists and engineers in R&D, by number of years since Ph.D. award and field: 1973-89

(page 2 of 2)

	Total	1-3 years	4-7 years	8-10 years	11-15 years	More than 15 years
	Social sciences and psychology					
	Percent					
1973......	68.2	74.9	69.4	66.9	62.1	65.1
1975......	63.9	74.4	66.9	62.6	57.3	57.3
1977......	53.6	57.3	55.5	55.5	49.6	50.8
1979......	52.4	60.9	56.2	55.3	47.9	45.7
1981......	53.0	62.8	58.3	52.9	48.6	48.1
1983......	51.1	62.5	60.4	56.0	46.0	44.2
1985......	50.9	57.6	55.0	59.1	48.4	45.8
1987......	67.5	75.3	73.5	70.9	67.3	62.7
1989......	68.9	77.8	77.9	71.8	69.2	63.9
	Engineering					
1973......	84.5	86.5	88.2	84.0	86.9	76.5
1975......	76.5	82.9	80.7	77.1	74.3	70.5
1977......	75.2	82.5	77.2	73.0	75.2	72.4
1979......	77.8	90.5	86.4	67.0	76.6	75.1
1981......	63.9	87.1	74.3	68.7	54.7	59.1
1983......	69.7	83.0	80.2	66.5	73.1	60.9
1985......	68.2	87.5	75.2	71.5	60.0	63.8
1987......	84.0	94.4	88.1	91.3	81.2	80.1
1989......	83.5	94.3	95.6	85.2	85.3	77.1

NOTE: "Active in R&D" is defined as those individuals who report R&D as either their primary or secondary activity.

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-11.

Science & Engineering Indicators – 1991

Appendix table 5-24.

Science and engineering doctorate-holders active in academic R&D reporting U.S. Government support, by field and years since Ph.D. award: 1973-89

(page 1 of 2)

	Total	1-3 years	4-7 years	8-10 years	11-15 years	More than 15 years
			Physical sciences			
			Percent			
1973	54.7	67.1	50.0	51.3	54.2	52.8
1975	53.1	67.3	50.3	50.3	49.5	52.6
1977	54.4	68.5	56.5	48.4	53.9	50.3
1979	56.7	70.7	53.8	51.7	56.8	54.7
1981	59.0	76.1	61.1	65.0	52.0	54.4
1983	63.9	76.5	74.2	72.0	57.6	59.6
1985	•	•	•	•	•	•
1987	65.6	79.8	68.4	72.9	70.6	60.1
1989	68.9	78.1	72.7	73.9	66.6	65.6
			Mathematical and computer sciences			
1973	34.7	25.3	35.0	29.6	45.9	42.7
1975	24.6	15.1	23.1	31.5	26.0	29.0
1977	25.5	23.7	24.7	27.0	23.9	27.7
1979	28.2	24.9	44.7	26.7	16.9	29.7
1981	27.5	24.2	35.0	31.0	31.3	19.4
1983	41.1	42.4	46.3	49.7	40.3	35.7
1985	•	•	•	•	•	•
1987	38.7	30.9	43.8	49.9	38.1	36.6
1989	41.5	34.1	51.6	51.8	48.4	35.6
			Environmental sciences			
1973	61.8	63.5	68.9	57.1	64.2	54.0
1975	60.8	60.8	66.9	61.8	61.1	53.4
1977	57.6	48.0	63.8	64.5	55.2	55.7
1979	63.9	84.5	64.1	62.9	61.1	54.8
1981	58.0	63.6	71.3	55.8	48.1	54.5
1983	68.3	72.6	70.6	79.9	63.3	63.0
1985	•	•	•	•	•	•
1987	68.4	67.2	69.8	80.9	75.6	62.0
1989	72.3	64.4	78.1	85.1	82.6	65.1
			Life sciences			
1973	67.7	67.9	67.3	68.7	67.0	67.6
1975	65.8	67.2	64.9	67.4	65.3	64.6
1977	67.5	69.7	68.1	70.2	67.1	64.5
1979	66.1	68.1	65.4	66.1	66.9	65.1
1981	63.8	73.3	67.4	62.0	62.3	58.2
1983	70.4	72.1	74.5	74.5	70.7	65.7
1985	•	•	•	•	•	•
1987	73.0	72.8	75.6	79.8	76.1	68.3
1989	74.0	79.0	75.9	77.6	79.2	68.3
			Social sciences and psychology			
1973	35.0	30.7	37.3	36.0	35.2	36.2
1975	31.4	25.5	32.7	35.0	31.1	33.6
1977	32.8	28.5	32.4	32.0	37.6	33.9
1979	33.2	33.5	31.9	34.3	34.7	32.5
1981	30.9	35.7	32.0	27.3	30.0	30.0
1983	34.7	38.9	37.1	31.4	37.0	31.1
1985	•	•	•	•	•	•
1987	32.6	31.2	37.2	31.6	33.5	30.8
1989	34.7	35.9	37.3	38.2	37.0	31.6

(continued)

Appendix table 5-24.

Science and engineering doctorate-holders active in academic R&D reporting U.S. Government support, by field and years since Ph.D. award: 1973-89

(page 2 of 2)

	Total	1-3 years	4-7 years	8-10 years	11-15 years	More than 15 years
			Engineering			
			Percent			
1973......	60.9	54.2	58.5	59.6	71.0	63.9
1975......	59.0	62.3	61.4	54.7	59.8	57.5
1977......	60.6	64.1	61.1	59.9	58.4	61.3
1979......	60.7	56.5	69.5	61.7	57.2	59.6
1981......	59.9	51.2	75.3	63.8	61.6	53.5
1983......	64.3	47.4	68.4	78.2	63.8	66.4
1985......	*	*	*	*	*	*
1987......	66.6	53.5	76.4	69.0	71.4	64.8
1989......	65.4	54.3	76.6	63.5	76.7	62.0

* = results for 1985 are discontinuous with other years because of substantial changes in questionnaire item content

SOURCES: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 1989*, NSF 91-317, Detailed Statistical Tables (Washington, DC: NSF, 1991); and unpublished tabulations.

See figure 5-12. *Science & Engineering Indicators – 1991*

Appendix table 5-25.

Full-time graduate students in science and engineering supported by research assistantships (RA), by source and field: 1972-89

(page 1 of 4)

	Total	Federal support	RA	Federal RA support	Non-Federal RA support	Total RA support	Federal RA support	Non-Federal RA support
Total science and engineering								
	Number					Percent		
1972	159,520	46,913	34,297	20,666	13,631	21.5	13.0	8.5
1973	161,902	42,745	35,944	20,589	15,355	22.2	12.7	9.5
1974	191,471	46,848	39,507	22,266	17,241	20.6	11.6	9.0
1975	220,489	47,182	40,006	23,045	16,961	18.1	10.5	7.7
1976	224,115	49,116	42,592	24,352	18,240	19.0	10.9	8.1
1977	227,862	50,958	43,743	25,125	18,618	19.2	11.0	8.2
1978	209,572	50,038	NA	NA	NA	NA	NA	NA
1979	233,089	52,880	49,118	28,045	21,073	21.1	12.0	9.0
1980	239,855	53,164	51,716	29,352	22,364	21.6	12.2	9.3
1981	243,671	51,085	52,880	29,176	23,704	21.7	12.0	9.7
1982	246,218	47,593	52,701	28,320	24,381	21.4	11.5	9.9
1983	253,735	47,909	55,069	29,173	25,896	21.7	11.5	10.2
1984	255,597	47,921	57,863	29,467	28,396	22.6	11.5	11.1
1985	259,467	49,230	61,162	30,442	30,720	23.6	11.7	11.8
1986	268,404	51,545	66,224	32,761	33,463	24.7	12.2	12.5
1987	273,434	53,780	70,384	35,013	35,371	25.7	12.8	12.9
1988	278,167	55,768	74,727	36,781	37,946	26.9	13.2	13.6
1989	286,619	57,921	79,151	38,314	40,837	27.6	13.4	14.2
Physical sciences								
1972	22,253	7,617	6,651	5,559	1,092	29.9	25.0	4.9
1973	21,060	6,346	6,305	5,079	1,226	29.9	24.1	5.8
1974	21,267	6,157	6,395	5,299	1,096	30.1	24.9	5.2
1975	21,916	6,210	6,441	5,487	954	29.4	25.0	4.4
1976	22,252	6,400	6,789	5,686	1,103	30.5	25.6	5.0
1977	22,505	6,628	6,810	5,770	1,040	30.3	25.6	4.6
1978	21,516	6,943	NA	NA	NA	NA	NA	NA
1979	22,535	7,496	7,806	6,512	1,294	34.6	28.9	5.7
1980	22,918	7,707	8,340	6,980	1,360	36.4	30.5	5.9
1981	23,308	7,956	8,607	7,271	1,336	36.9	31.2	5.7
1982	24,040	7,713	8,768	7,095	1,673	36.5	29.5	7.0
1983	25,205	8,126	9,145	7,471	1,674	36.3	29.6	6.6
1984	25,852	8,640	9,628	7,807	1,821	37.2	30.2	7.0
1985	26,669	8,821	10,284	8,065	2,219	38.6	30.2	8.3
1986	27,764	9,523	10,994	8,665	2,329	39.6	31.2	8.4
1987	28,414	9,717	11,558	8,873	2,685	40.7	31.2	9.4
1988	28,574	9,857	12,056	8,968	3,088	42.2	31.4	10.8
1989	29,164	10,276	12,413	9,160	3,253	42.6	31.4	11.2
Mathematical and computer sciences								
1972	13,273	2,072	1,344	847	497	10.1	6.4	3.7
1973	13,277	1,957	1,321	824	497	9.9	6.2	3.7
1974	13,755	1,581	1,414	828	586	10.3	6.0	4.3
1975	15,168	1,436	1,375	752	623	9.1	5.0	4.1
1976	15,700	1,481	1,528	795	733	9.7	5.1	4.7
1977	14,969	1,490	1,508	877	631	10.1	5.9	4.2
1978	13,733	1,471	NA	NA	NA	NA	NA	NA
1979	15,521	1,654	1,642	1,005	637	10.6	6.5	4.1

(continued)

Appendix table 5-25.

Full-time graduate students in science and engineering supported by research assistantships (RA), by source and field: 1972-89

(page 2 of 4)

	Total	Federal support	RA	Federal RA support	Non-Federal RA support	Total RA support	Federal RA support	Non-Federal RA support
				Mathematical and computer sciences				
	Number					Percent		
1980	16,489	1,821	1,820	1,099	721	11.0	6.7	4.4
1981	17,599	1,804	1,858	1,055	803	10.6	6.0	4.6
1982	19,994	1,893	2,036	1,140	896	10.2	5.7	4.5
1983	21,651	1,890	2,206	1,193	1,013	10.2	5.5	4.7
1984	22,906	2,031	2,507	1,382	1,125	10.9	6.0	4.9
1985	25,934	2,573	3,074	1,551	1,523	11.9	6.0	5.9
1986	27,708	2,891	3,392	1,686	1,706	12.2	6.1	6.2
1987	28,640	3,175	3,948	2,142	1,806	13.8	7.5	6.3
1988	29,150	3,416	4,281	2,312	1,969	14.7	7.9	6.8
1989	29,818	3,614	4,506	2,330	2,176	15.1	7.8	7.3
				Mathematical sciences				
1972	10,372	1,393	706	442	264	6.8	4.3	2.5
1973	10,339	1,222	668	373	295	6.5	3.6	2.9
1974	10,009	860	667	351	316	6.7	3.5	3.2
1975	10,695	693	629	300	329	5.9	2.8	3.1
1976	10,952	784	797	409	388	7.3	3.7	3.5
1977	10,365	786	784	403	381	7.6	3.9	3.7
1978	9,307	772	NA	NA	NA	NA	NA	NA
1979	9,668	864	825	424	401	8.5	4.4	4.1
1980	9,902	868	784	421	363	7.9	4.3	3.7
1981	10,154	796	760	340	420	7.5	3.3	4.1
1982	10,823	818	845	377	468	7.8	3.5	4.3
1983	10,964	760	803	350	453	7.3	3.2	4.1
1984	11,319	762	872	411	461	7.7	3.6	4.1
1985	11,833	935	998	478	520	8.4	4.0	4.4
1986	12,398	999	1,038	538	500	8.4	4.3	4.0
1987	13,068	1,091	1,111	635	476	8.5	4.9	3.6
1988	13,554	1,190	1,227	666	561	9.1	4.9	4.1
1989	13,792	1,267	1,304	662	642	9.5	4.8	4.7
				Computer sciences				
1972	2,901	679	638	405	233	22.0	14.0	8.0
1973	2,938	735	653	451	202	22.2	15.4	6.9
1974	3,746	721	747	477	270	19.9	12.7	7.2
1975	4,473	743	746	452	294	16.7	10.1	6.6
1976	4,748	697	731	386	345	15.4	8.1	7.3
1977	4,604	704	724	474	250	15.7	10.3	5.4
1978	4,426	699	NA	NA	NA	NA	NA	NA
1979	5,853	790	817	581	236	14.0	9.9	4.0
1980	6,587	953	1,036	678	358	15.7	10.3	5.4
1981	7,445	1,008	1,098	715	383	14.7	9.6	5.1
1982	9,171	1,075	1,191	763	428	13.0	8.3	4.7
1983	10,687	1,130	1,403	843	560	13.1	7.9	5.2
1984	11,587	1,269	1,635	971	664	14.1	8.4	5.7
1985	14,101	1,638	2,076	1,073	1,003	14.7	7.6	7.1
1986	15,310	1,892	2,354	1,148	1,206	15.4	7.5	7.9
1987	15,572	2,084	2,837	1,507	1,330	18.2	9.7	8.5
1988	15,596	2,226	3,054	1,646	1,408	19.6	10.6	9.0
1989	16,026	2,347	3,202	1,668	1,534	20.0	10.4	9.6

(continued)

Appendix table 5-25.

Full-time graduate students in science and engineering supported by research assistantships (RA), by source and field: 1972-89

(page 3 of 4)

	Total	Federal support	RA	Federal RA support	Non-Federal RA support	Total RA support	Federal RA support	Non-Federal RA support
	Environmental sciences							
	Number					Percent		
1972	7,210	2,619	2,398	1,666	732	33.3	23.1	10.2
1973	7,767	2,480	2,551	1,780	771	32.8	22.9	9.9
1974	8,335	2,561	2,665	1,941	724	32.0	23.3	8.7
1975	9,677	2,693	2,838	2,089	749	29.3	21.6	7.7
1976	10,219	2,964	3,196	2,287	909	31.3	22.4	8.9
1977	10,556	3,117	3,234	2,318	916	30.6	22.0	8.7
1978	10,012	3,169	NA	NA	NA	NA	NA	NA
1979	10,724	3,523	3,587	2,706	881	33.4	25.2	8.2
1980	10,969	3,442	3,770	2,702	1,068	34.4	24.6	9.7
1981	11,038	3,010	3,469	2,402	1,067	31.4	21.8	9.7
1982	11,436	2,854	3,339	2,323	1,016	29.2	20.3	8.9
1983	12,049	2,874	3,545	2,348	1,197	29.4	19.5	9.9
1984	11,819	2,848	3,574	2,324	1,250	30.2	19.7	10.6
1985	11,439	2,960	3,723	2,410	1,313	32.5	21.1	11.5
1986	11,323	3,033	3,834	2,372	1,462	33.9	20.9	12.9
1987	10,543	2,868	3,660	2,251	1,409	34.7	21.4	13.4
1988	10,296	2,799	3,891	2,317	1,574	37.8	22.5	15.3
1989	10,088	2,842	4,124	2,394	1,730	40.9	23.7	17.1
	Life sciences							
1972	36,751	12,868	8,742	4,023	4,719	23.8	10.9	12.8
1973	40,830	12,563	9,461	4,292	5,169	23.2	10.5	12.7
1974	55,048	16,802	10,851	5,025	5,826	19.7	9.1	10.6
1975	63,513	17,594	11,322	5,373	5,949	17.8	8.5	9.4
1976	66,235	18,237	12,593	6,045	6,548	19.0	9.1	9.9
1977	68,828	19,465	13,077	6,172	6,905	19.0	9.0	10.0
1978	65,257	19,634	NA	NA	NA	NA	NA	NA
1979	71,150	21,240	15,421	7,230	8,191	21.7	10.2	11.5
1980	72,409	21,317	15,910	7,634	8,276	22.0	10.5	11.4
1981	72,241	20,476	16,362	7,606	8,756	22.6	10.5	12.1
1982	70,254	18,389	16,251	7,287	8,964	23.1	10.4	12.8
1983	70,062	17,678	16,514	7,272	9,242	23.6	10.4	13.2
1984	70,597	17,787	17,602	7,400	10,202	24.9	10.5	14.5
1985	70,311	18,604	17,932	7,996	9,936	25.5	11.4	14.1
1986	71,285	19,014	19,257	8,571	10,686	27.0	12.0	15.0
1987	72,463	20,213	20,301	9,377	10,924	28.0	12.9	15.1
1988	74,168	20,807	21,654	10,069	11,585	29.2	13.6	15.6
1989	77,001	21,931	23,264	10,872	12,392	30.2	14.1	16.1
	Psychology							
1972	15,308	4,708	1,777	1,006	771	11.6	6.6	5.0
1973	15,191	4,166	1,930	913	1,017	12.7	6.0	6.7
1974	19,044	4,425	2,291	1,042	1,249	12.0	5.5	6.6
1975	24,109	4,330	2,213	1,006	1,207	9.2	4.2	5.0
1976	25,649	4,311	2,261	977	1,284	8.8	3.8	5.0
1977	25,710	4,261	2,312	1,039	1,273	9.0	4.0	5.0
1978	20,740	3,937	NA	NA	NA	NA	NA	NA
1979	25,865	3,603	2,528	1,170	1,358	9.8	4.5	5.38

(continued)

Appendix table 5-25.

Full-time graduate students in science and engineering supported by research assistantships (RA), by source and field: 1972-89

(page 4 of 4)

	Total	Federal support	RA	Federal RA support	Non-Federal RA support	Total RA support	Federal RA support	Non-Federal RA support
Psychology								
	Number					Percent		
1980	26,692	3,390	2,571	942	1,629	9.6	3.5	6.1
1981	26,725	3,055	2,890	1,036	1,854	10.8	3.9	6.9
1982	25,818	2,414	2,723	927	1,796	10.5	3.6	7.0
1983	26,701	2,141	2,962	944	2,018	11.1	3.5	7.6
1984	26,108	2,062	3,027	962	2,065	11.6	3.7	7.9
1985	25,769	2,057	3,082	1,017	2,065	12.0	3.9	8.0
1986	26,521	2,035	3,119	1,021	2,098	11.8	3.8	7.9
1987	27,426	2,052	3,231	1,078	2,153	11.8	3.9	7.9
1988	28,412	2,167	3,743	1,210	2,533	13.2	4.3	8.9
1989	30,221	2,208	3,900	1,271	2,629	12.9	4.2	8.7
Social sciences								
1972	32,534	5,553	3,654	1,149	2,505	11.2	3.5	7.7
1973	32,551	4,765	3,996	1,147	2,849	12.3	3.5	8.8
1974	40,285	5,133	4,788	1,350	3,438	11.9	3.4	8.5
1975	48,293	4,656	4,830	1,403	3,427	10.0	2.9	7.1
1976	47,096	5,148	4,897	1,349	3,548	10.4	2.9	7.5
1977	47,729	5,360	4,925	1,399	3,526	10.3	2.9	7.4
1978	41,257	4,433	NA	NA	NA	NA	NA	NA
1979	46,901	4,553	5,223	1,408	3,815	11.1	3.0	8.1
1980	47,271	4,296	5,298	1,447	3,851	11.2	3.1	8.1
1981	46,503	3,810	5,212	1,271	3,941	11.2	2.7	8.5
1982	44,437	3,235	4,883	971	3,912	11.0	2.2	8.8
1983	43,740	3,215	5,059	935	4,124	11.6	2.1	9.4
1984	42,776	2,963	5,180	916	4,264	12.1	2.1	10.0
1985	43,052	2,948	5,102	976	4,126	11.9	2.3	9.6
1986	43,077	2,670	5,138	888	4,250	11.9	2.1	9.9
1987	43,719	2,624	5,517	921	4,596	12.6	2.1	10.5
1988	44,089	2,691	5,634	925	4,709	12.8	2.1	10.7
1989	45,747	2,797	6,308	1,005	5,303	13.8	2.2	11.6
Engineering								
1972	32,191	11,476	9,731	6,416	3,315	30.2	19.9	10.3
1973	31,226	10,468	10,380	6,554	3,826	33.2	21.0	12.3
1974	33,737	10,189	11,103	6,781	4,322	32.9	20.1	12.8
1975	37,813	10,263	10,987	6,935	4,052	29.1	18.3	10.7
1976	36,964	10,575	11,328	7,213	4,115	30.6	19.5	11.1
1977	37,565	10,637	11,877	7,550	4,327	31.6	20.1	11.5
1978	37,057	10,451	NA	NA	NA	NA	NA	NA
1979	40,393	10,811	12,911	8,014	4,897	32.0	19.8	12.1
1980	43,107	11,191	14,007	8,548	5,459	32.5	19.8	12.7
1981	46,257	10,974	14,482	8,535	5,947	31.3	18.5	12.9
1982	50,239	11,095	14,701	8,577	6,124	29.3	17.1	12.2
1983	54,327	11,985	15,638	9,010	6,628	28.8	16.6	12.2
1984	55,539	11,590	16,345	8,676	7,669	29.4	15.6	13.8
1985	56,293	11,267	17,965	8,427	9,538	31.9	15.0	16.9
1986	60,726	12,379	20,490	9,558	10,932	33.7	15.7	18.0
1987	62,229	13,131	22,169	10,371	11,798	35.6	16.7	19.0
1988	63,478	14,031	23,468	10,980	12,488	37.0	17.3	19.7
1989	64,580	14,253	24,636	11,282	13,354	38.1	17.5	20.7

NA = not available

SOURCE: Science Resources Studies Division, National Science Foundation, *Academic Science and Engineering: Graduate Enrollment and Support, Fall 1989,* Detailed Statistical Tables, NSF 90-324 Final (Washington, DC: NSF, 1991).

See figure 5-13.

Appendix table 5-26.
U.S. and world scientific and technical articles, by field: 1973-87

Field	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
U.S. articles as percentage of all articles															
Total	38.2	37.7	37.3	37.4	37.1	36.7	37.1	36.5	35.9	35.9	35.4	35.4	35.3	35.6	35.6
Clinical medicine	42.8	42.5	42.6	43.0	43.2	43.1	43.1	43.0	41.3	41.1	40.3	40.9	40.3	40.0	39.9
Biomedical research	39.2	38.4	38.6	38.8	39.1	38.7	40.5	39.7	39.5	39.7	39.3	39.5	37.8	38.4	38.2
Biology	46.4	45.7	44.7	44.2	41.7	41.7	42.7	42.0	37.6	38.4	37.6	37.2	37.5	38.1	37.3
Chemistry	23.3	22.2	21.7	21.8	21.7	21.1	21.2	20.8	20.0	21.2	20.3	20.6	21.0	22.2	22.2
Physics	32.7	33.5	32.4	31.2	30.5	30.8	30.0	30.1	28.6	28.1	27.8	27.3	29.4	30.3	30.1
Earth and space sciences	46.7	46.8	43.8	46.1	45.1	44.9	44.6	42.4	42.7	42.4	41.6	41.3	43.0	42.6	42.6
Engineering and technology	41.8	41.7	40.6	41.1	40.2	39.4	40.7	39.4	40.7	40.6	40.9	39.5	38.6	37.3	37.9
Mathematics	47.9	46.0	44.0	42.9	41.1	40.4	40.5	39.7	38.2	39.0	38.5	37.2	38.3	40.3	40.7
Number of U.S. articles															
Total	103,778	100,066	97,278	99,970	97,854	99,207	99,377	98,394	132,278	133,622	132,413	131,111	137,771	137,770	134,497
Clinical medicine	32,638	31,691	31,334	32,920	33,516	34,966	33,975	34,612	48,072	48,530	48,055	48,735	50,595	50,637	49,904
Biomedical research	16,115	15,607	15,901	16,271	16,197	16,611	17,649	17,582	21,847	22,732	22,496	22,196	24,461	24,765	24,542
Biology	11,150	10,700	10,400	10,573	9,904	9,663	10,553	9,594	14,740	14,974	14,216	14,166	13,083	13,000	12,231
Chemistry	10,474	9,867	9,222	9,337	8,852	9,266	9,182	9,250	10,880	11,758	11,010	11,137	11,585	12,313	11,827
Physics	11,721	11,945	11,363	11,502	10,995	11,015	10,995	11,415	13,053	13,255	13,021	12,691	15,903	16,360	16,078
Earth and space sciences	5,591	5,371	4,975	5,537	5,197	5,043	5,167	4,832	7,257	7,057	6,862	6,748	7,663	7,811	7,797
Engineering and technology	11,955	11,088	10,431	10,346	10,081	9,694	9,018	8,461	12,486	11,619	13,105	11,976	10,822	9,775	9,225
Mathematics	4,134	3,797	3,652	3,484	3,112	2,949	2,838	2,648	3,943	3,697	3,648	3,462	3,659	3,109	2,893
Total number of articles															
Total	271,512	265,130	260,908	267,354	263,700	270,126	267,954	269,557	368,934	371,760	373,549	369,930	389,846	387,028	378,313
Clinical medicine	76,209	74,509	73,485	76,599	77,597	81,207	78,827	80,533	116,371	118,186	119,325	119,094	125,532	126,463	124,975
Biomedical research	41,155	40,632	41,244	41,891	41,388	42,968	43,631	44,267	55,303	57,203	57,289	56,223	64,717	64,550	64,216
Biology	24,047	23,414	23,260	23,905	23,757	23,176	24,734	22,838	39,232	39,025	37,788	38,093	34,896	34,127	32,775
Chemistry	45,004	44,529	42,502	42,773	40,734	43,850	43,273	44,448	54,432	55,381	54,186	54,117	55,268	55,558	53,236
Physics	35,864	35,708	35,104	36,902	36,057	35,815	36,700	37,944	45,561	47,229	46,902	46,450	54,044	54,056	53,377
Earth and space sciences	11,977	11,479	11,356	12,011	11,531	11,224	11,596	11,395	16,991	16,660	16,508	16,334	17,834	18,351	18,285
Engineering and technology	28,617	26,600	25,664	25,146	25,063	24,588	22,182	21,459	30,710	28,602	32,073	30,310	28,004	26,201	24,344
Mathematics	8,639	8,259	8,293	8,127	7,573	7,298	7,011	6,673	10,334	9,474	9,478	9,309	9,551	7,722	7,105

NOTES: Articles written by researchers from more than one country are prorated according to the number of author institutions in each country. For example, a paper authored by two U.S. scientists and one French scientist would be counted as two-thirds of a U.S. article and one-third of a French article. Data are based on more than 3,200 U.S. and foreign journals on the 1981 Science Citation Index Corporate Tapes.

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Data Base, 1989, special tabulations.

Science & Engineering Indicators – 1991

Appendix table 5-27.
Contribution of selected countries to world literature, by field: 1981 and 1987

Field	Total articles	United States	Total European Community countries	United Kingdom	West Germany	France	USSR	Japan	Canada
1981									
		Percent							
Total	368,934	35.9	26.3	8.3	7.3	5.0	8.0	6.8	3.9
Clinical medicine	116,371	41.3	28.9	9.8	7.0	5.2	3.3	5.1	3.4
Biomedical research	55,303	39.5	26.9	8.5	7.1	5.2	5.7	6.2	4.1
Biology	39,232	37.6	22.4	9.0	6.0	3.5	2.8	6.1	6.3
Chemistry	54,432	20.0	26.2	6.6	8.4	5.9	16.7	10.9	3.1
Physics	45,561	28.6	25.8	6.4	7.7	5.9	16.8	8.2	2.9
Earth and space sciences	16,991	42.7	22.8	8.5	4.9	4.6	10.0	2.3	5.2
Engineering and technology	30,710	40.7	22.9	8.5	7.6	3.3	7.6	9.2	4.2
Mathematics	10,334	38.2	26.2	6.1	11.0	5.6	7.6	4.3	5.1
1987									
Total	378,313	35.6	26.5	8.0	6.8	4.8	7.3	7.6	4.4
Clinical medicine	124,975	39.9	28.9	10.0	6.2	4.5	2.8	6.7	4.1
Biomedical research	64,216	38.2	25.5	7.6	6.4	5.0	8.0	7.1	4.3
Biology	32,775	37.3	22.4	8.8	5.6	3.2	2.3	6.9	8.6
Chemistry	53,236	22.2	27.5	6.0	8.8	5.9	13.9	10.8	3.2
Physics	53,377	30.1	26.2	5.6	8.1	6.0	14.3	8.5	2.8
Earth and space sciences	18,285	42.6	22.6	7.3	4.6	4.8	7.1	3.5	6.8
Engineering and technology	24,344	37.9	22.5	7.5	7.6	3.4	5.6	10.1	5.1
Mathematics	7,105	40.7	28.6	8.6	6.7	5.0	4.8	3.6	4.5

NOTES: Articles written by researchers from more than one country are prorated according to the number of author institutions in each country. For example, a paper authored by two U.S. scientists and one French scientist would be counted as two-thirds of a U.S. article and one-third of a French article. Data are based on more than 3,200 U.S. and foreign journals on the 1981 Science Citation Index Corporate Tapes.

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Data Base, 1989, special tabulations.

See figure O-18 in Overview.

Science & Engineering Indicators – 1991

Appendix table 5-28.

Patents awarded to U.S. universities, by technology class: 1969-90

(page 1 of 7)

Technology class	1969-75	1976-80	1981-85	1986-90
Total	1,694	1,739	2,462	4,664
1 Unclassified	5	1	1	30
2 Apparel	0	1	4	3
4 Baths, closets, sinks, spittoons	0	1	0	0
5 Beds	1	1	0	2
8 Bleaching & dying; fluid treatment & chemical modification of textiles & fibers	1	3	3	2
15 Brushing, scrubbing & general cleaning	5	1	1	0
17 Butchering	0	0	0	0
19 Textiles, fiber preparation	0	1	0	0
23 Chemistry, physical processes	1	0	2	0
24 Buckles, buttons, clasps	0	0	0	2
27 Undertaking	0	0	0	1
29 Metal working	7	1	1	10
33 Geometrical instruments	0	2	2	2
34 Drying & gas or vapor contact with solids	2	4	3	1
37 Excavating	1	1	1	0
40 Card, picture & sign exhibiting	0	1	0	1
43 Fishing, trapping & vermin destroying	1	1	1	2
44 Fuel & related compositions	0	2	17	12
47 Plant husbandry	5	10	14	9
48 Gas, heating & illuminating	3	5	4	1
51 Abrading	4	4	0	3
52 Static structures, buildings	4	2	8	5
53 Package making	2	1	0	0
54 Harness	0	0	0	1
55 Gas separation	13	8	13	20
56 Harvesters	34	9	7	4
60 Power plants	6	6	8	7
62 Refrigeration	7	10	15	19
65 Glass manufacturing	6	2	1	12
70 Locks	0	0	1	1
71 Chemistry, fertilizers	5	8	8	26
72 Metal deforming	6	1	1	0
73 Measuring and testing	69	59	71	105
74 Machine elements & mechanisms	6	7	5	8
75 Metallurgy	8	9	10	14
76 Metal tools & implements - making	0	0	1	0
81 Tools	0	0	0	2
82 Turning	0	1	0	0
83 Cutting	4	0	1	1
84 Music	3	4	3	3
87 Textiles, braiding, netting, lace making	0	0	0	1
89 Ordnance	0	0	0	7
91 Motors, expansible chamber type	1	0	0	1
92 Expansible chamber devices	0	0	2	2
98 Ventilation	2	0	0	0
99 Foods & beverages - apparatus	1	2	3	1
100 Presses	2	1	1	1
101 Printing	2	0	0	0
102 Ammunition & explosives	0	1	0	1
104 Railways	10	1	2	6

(continued)

Appendix table 5-28.

Patents awarded to U.S. universities, by technology class: 1969-90

(page 2 of 7)

Technology class		1969-75	1976-80	1981-85	1986-90
106	Compositions, coating or plastic	6	6	6	6
108	Horizontally supported planar surfaces	1	1	4	0
110	Furnaces	1	0	10	3
111	Planting	4	0	7	8
112	Sewing	0	0	0	1
114	Ships	1	1	1	0
116	Signals & indicators	1	0	0	1
118	Coating apparatus	5	3	4	5
119	Animal husbandry	5	6	7	19
122	Liquid heaters & vaporizers	1	0	1	4
123	Internal combustion engines	5	9	5	15
124	Mechanical guns & projectors	0	1	0	0
125	Stone working	0	0	0	1
126	Stoves & furnaces	2	16	13	3
127	Sugar, starch & carbohydrates	0	3	11	1
128	Surgery	68	67	110	224
131	Tobacco	4	2	0	4
132	Toilet	1	0	0	0
134	Cleaning & liquid contact with solids	0	4	7	4
135	Tents canopies umbrellas & canes	1	0	0	1
136	Batteries, thermoelectric & photoelectric	2	15	28	4
137	Fluid handling	13	7	3	5
138	Pipes & tubular conduits	0	0	1	1
139	Textiles, weaving	0	0	1	0
141	Fluent materials handling with receiver or receiver coating means	1	4	1	1
144	Woodworking	2	0	2	0
148	Metal treatment	2	11	11	15
149	Explosives & thermic compositions & charges	1	0	0	0
156	Adhesive bonding & misc. chemical manufacture	5	6	19	48
159	Concentrating evaporators	0	0	1	1
160	Closures, partitions & panels, flexible & portable	0	0	1	0
162	Paper making & fiber liberation	0	1	3	4
164	Metal founding	3	3	5	4
165	Heat exchange	2	3	5	12
166	Wells	2	3	9	5
169	Fire extinguishers	0	0	1	0
171	Unearthing plants or buried objects	5	3	0	1
172	Earth working	0	7	1	0
173	Tool driving & impacting	1	0	1	2
174	Electricity conductors & insulators	2	3	0	3
175	Boring & penetrating earth	1	3	5	1
177	Weighing scales	1	0	0	2
178	Telegraphy	5	1	1	1
180	Motor vehicles	0	1	1	3
181	Acoustics	0	1	5	1
185	Motors, springs, weight & animal powered	1	0	0	0
188	Brakes	3	2	1	0
194	Check actuated control mechanisms	1	0	0	1
198	Conveyors power driven	6	1	7	0
200	Electricity, circuit makers & breakers	1	0	0	5

(continued)

Appendix table 5-28.

Patents awarded to U.S. universities, by technology class: 1969-90

(page 3 of 7)

Technology class	1969-75	1976-80	1981-85	1986-90
201 Distillation processes thermolytic	0	2	0	0
202 Distillation apparatus	1	0	0	1
203 Distillation processes separatory	0	2	3	5
204 Chemistry: electrical and wave energy	41	36	65	92
206 Receptacle or package, special	1	0	0	8
208 Mineral oils, processes & products	2	3	9	5
209 Classifying, separating & assorting solids	19	9	12	19
210 Liquid purification or separation	27	32	34	59
211 Supports, racks	1	0	2	0
215 Bottles & jars	2	0	0	0
219 Electric heating	6	8	9	15
220 Receptacles	1	0	1	2
221 Dispensing, article	1	1	1	1
222 Dispensing	2	4	3	2
225 Severing by tearing, breaking	1	0	0	0
226 Advancing material of indeterminate length	0	0	0	1
228 Metal fusion bonding	1	1	0	4
235 Registers	1	1	0	1
236 Automatic temperature & humidity regulation	0	0	0	1
238 Railways surface track	0	0	2	0
239 Fluid sprinkling, spraying, diffusing	3	1	4	7
241 Solid material comminution, disintegration	7	1	2	5
242 Winding & reeling	2	1	0	3
244 Aeronautics	8	3	2	4
248 Supports	2	0	0	3
249 Molds, static	1	0	0	0
250 Radiant energy	38	54	46	117
251 Valves, valve actuation	2	1	0	5
252 Compositions	10	15	20	26
254 Apparatus, implements for applying pushing, pulling force	1	1	0	0
256 Fences	0	0	0	1
260 Chemistry, carbon compounds	5	6	5	7
261 Gas, liquid contact apparatus	1	0	2	0
264 Plastic & nonmetallic article shaping and treating processes	9	18	19	31
266 Metallurgical apparatus	0	0	0	1
267 Device, spring	1	1	0	0
269 Work holders	0	1	1	1
272 Devices, amusement & exercising	1	0	3	12
273 Devices, amusement-games	1	5	0	3
277 Joint packing	0	0	0	5
279 Chucks, sockets	0	0	1	0
280 Vehicles, land	2	0	15	4
283 Printed matter	1	0	0	0
285 Pipe joints, couplings	1	0	0	0
289 Knots, knot tying	1	0	0	0
290 Dynamo plants, prime mover	1	2	2	0
292 Fasteners, closure	0	0	1	0
293 Vehicle fenders	1	0	0	0
294 Implements, handling-hand & hoist line	0	1	1	5
296 Vehicles, land-bodies & tops	0	2	1	0

(continued)

Appendix table 5-28.

Patents awarded to U.S. universities, by technology class: 1969-90

(page 4 of 7)

Technology class	1969-75	1976-80	1981-85	1986-90
297 Chairs, seats	1	0	0	1
299 Mining, in situ disintegration of hard material	2	1	1	2
307 Electrical transmission or interconnection systems	30	13	8	13
310 Electrical generator or motor structure	28	8	10	18
312 Supports, cabinet structures	2	1	1	0
313 Electric lamp & discharge devices	4	6	1	3
315 Electric lamp & discharge devices, systems	11	7	7	9
318 Electricity, motive power systems	9	5	5	4
320 Electricity, battery & condenser charging & discharging	1	0	1	1
322 Electricity, single generator systems	0	1	2	2
323 Electricity, power supply or regulation systems	3	1	1	2
324 Electricity: measuring and testing	30	16	37	129
328 Electricity, misc. electron space discharge device systems	3	2	4	5
329 Electr - demodulators & detectors	3	0	0	0
330 Amplifiers	13	6	5	13
331 Electr - amplifiers	8	4	2	6
332 Electr - oscillators	3	0	1	1
333 Wave transmission lines & networks	12	14	9	10
335 Electr - modulators	3	1	0	5
336 Electr - wave transmission lines & networks	2	0	0	0
338 Electr - tuners	6	2	1	5
340 Communications, electrical	18	8	7	18
341 Electr - magnetically operated switches magnets & electromagnets	5	2	1	13
342 Electr - inductor devices	12	7	3	8
343 Communications, radio wave antennas	18	5	5	3
346 Electr - switches electrothermically or thermically actuated	3	1	0	1
350 Optics, systems and elements	20	24	42	119
351 Electr - resistors	4	2	2	17
352 Electr - communications	1	0	0	2
353 Optics, image projectors	1	0	0	0
354 Photography	1	1	3	0
355 Photocopying	1	0	0	0
356 Optics, measuring and testing	19	24	31	86
357 Active solid state devices eg transistors, solid state diodes	10	17	19	60
358 Pictorial communication; television	14	14	12	39
360 Info tech - dynamic magnetic info storage & retrieval	10	5	1	3
361 Electr - electrical systems & devices	8	4	1	7
362 Electr - illumination	3	0	0	2
363 Electr - power conversion systems	3	8	7	12
364 Electrical computers and data processing systems	32	26	36	137

(continued)

Appendix table 5-28.

Patents awarded to U.S. universities, by technology class: 1969-90

(page 5 of 7)

Technology class	1969-75	1976-80	1981-85	1986-90
365 Static information storage & retrieval	24	7	7	23
366 Agitating	1	4	2	2
367 Electr - communications-acoustic wave systems & devices	11	6	0	9
368 Measuring: horology-time meas sys & devices	4	1	0	1
369 Info tech - dynamic info storage & retrieval	0	0	1	2
370 Electr - communications multiplex	3	2	2	13
371 Electr - error detection/correct and fault detect/recovery	2	1	4	7
372 Coherent light generators	15	14	27	74
373 Heating - industrial electric furnaces	2	0	0	1
374 Measuring - thermal meas & testing	1	6	9	14
375 Electr - communications, pulse or digital	5	2	2	9
376 Nuclear - induced reactions systems & elements	1	4	5	6
377 Electr - pulse counters, dividers; shift registers-circuits & systems	4	0	1	3
378 X-ray or gamma-ray systems or devices	17	25	17	33
379 Nuclear - x-ray gamma ray sys, devices	1	0	1	8
380 Cryptography	0	3	6	2
381 Electrical audio signal processing and systems and devices	6	7	12	18
382 Image analysis	1	1	5	14
384 Bearings	3	0	0	3
400 Typewriting machines	0	0	1	1
403 Joints & connections	0	2	0	1
404 Road structure process, apparatus	0	0	0	2
405 Earth, hydraulic engineering	6	2	6	6
406 Conveyors, fluid current	3	5	3	1
407 Cutters for shaping	0	0	0	2
409 Gear cutting, milling, planing	1	1	1	0
414 Handling, material/article	5	5	4	10
415 Motors, pumps-rotary kinetic fluid	0	2	1	0
416 Fluid reaction surfaces-impellers	0	1	1	0
417 Pumps	2	10	4	7
418 Expansible chamber devices-rotary	5	0	0	0
419 Powder metallurgy-processes	1	0	2	5
420 Compositions-alloys or metallic compositions	6	1	5	5
422 Process disinfecting, deodorizing, preserving or sterilizing & chemical apparatus	9	12	14	39
423 Chemistry, inorganic	37	30	26	31
424 Drug, bio-affecting and body treating compositions	52	69	137	261
425 Plastic or earthenware article shaping, treating apparatus	1	1	4	4
426 Food or edible material: processes, compositions and products	31	31	38	35
427 Coating processes	8	10	15	62
428 Stock material or miscellaneous articles	13	14	31	48
429 Chemistry, electrical current producing apparatus, product & process	5	12	22	17
430 Radiation imagery chemistry-process, composition or product	3	4	9	20

(continued)

Appendix table 5-28.
Patents awarded to U.S. universities, by technology class: 1969-90
(page 6 of 7)

Technology class	1969-75	1976-80	1981-85	1986-90
431 Combustion	2	1	1	3
432 Heating	0	1	3	0
433 Dentistry	4	10	3	17
434 Education & demonstration	21	4	4	8
435 Chemistry: molecular biology and microbiology	58	84	192	446
436 Chemistry: analytical and immunological testing	23	56	72	65
437 Semiconductor device manufacturing, process	5	14	26	50
439 Electr - connectors	0	0	1	4
440 Propulsion-marine	0	0	0	1
445 Electrical lamp etc	1	0	1	0
449 Bee culture	0	0	1	0
452 Butchering	4	1	2	0
455 Telecommunications	10	4	6	5
460 Crop threshing, separating	7	2	1	0
474 Rotary shafts etc. & flecible couplings for	0	0	0	3
494 Imperforate bowl, centrifugal separators	0	0	1	0
501 Compositions-ceramic	0	5	6	21
502 Catalyst, solid sorbent, or support therefor, product or process of making	2	8	11	22
503 Record receiver with plural leaves or colorless color former	1	0	0	0
505 Superconductor technology-apparat;mat; process	0	0	0	25
514 Drug, bio-affecting and body treating compositions	46	119	225	464
518 Chemistry- F/T processes; puri/recov of products	0	0	1	1
521 Synthetic resins or nat rubbers- cf class 520 series	10	8	5	5
522 Synthetic resins or nat rubbers- cf class 520 series	1	3	1	4
523 Synthetic resins or nat rubbers- cf class 520 series	3	3	6	6
524 Synthetic resins or nat rubbers- cf class 520 series	7	4	3	8
525 Synthetic resins or natural rubber- part of class 520 series	4	21	24	38
526 Synthetic resins or nat rubbers- cf class 520 series	4	5	3	19
527 Synthetic resins or nat rubbers- cf class 520 series	1	0	2	1
528 Synthetic resins or natural rubber- part of class 520 series	20	13	6	30
530 Chemistry: peptides or proteins; lignins or reaction products thereof	9	14	79	117
534 Organic compounds - cf class 532-570 series	4	5	2	9
536 Organic compounds - part of class 532-570 series	19	23	35	65
540 Organic compounds-part of class 532-570 series	8	13	11	36
544 Organic compounds - cf class 532-570 series	5	4	9	20

(continued)

Appendix table 5-28.

Patents awarded to U.S. universities, by technology class: 1969-90

(page 7 of 7)

Technology class	1969-75	1976-80	1981-85	1986-90
546 Organic compounds-part of class 532-570 series	15	23	9	29
548 Organic compounds-part of class 532-570 series	4	14	10	24
549 Organic compounds-part of class 532-570 series	8	28	37	40
552 Organic compounds - cf class 532-570 series	25	25	31	15
556 Organic compounds-part of class 532-570 series	10	7	13	26
558 Organic compounds-part of class 532-570 series	6	5	8	12
560 Organic compounds-part of class 532-570 series	12	20	16	13
562 Organic compounds-part of class 532-570 series	10	8	5	9
564 Organic compounds - cf class 532-570 series	7	7	5	10
568 Organic compounds-part of class 532-570 series	19	23	14	15
570 Organic compounds - cf class 532-570 series	2	0	1	3
585 Chemistry-hydrocarbons	4	6	6	14
600 Surgery	5	5	11	13
604 Surgery	7	11	36	78
606 Surgery	14	8	21	54
623 Prosthesis, parts thereof or aids and accessories therefor	21	14	22	54
800 Multicellular living organisms or parts	1	1	3	2

SOURCE: TAF Report, U.S. Universities, U.S. Patent and Trademark Office, July 1991.

See figure 5-14.

Science & Engineering Indicators – 1991

Appendix table 5-29.

Patents awarded to the 100 academic institutions with the greatest R&D volume: 1969-90

(page 1 of 3)

	Total 1969-90	1969-71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ALL ACADEMIC PATENTS	10,559	630	237	258	249	320	357	363	367	262	390	436	457	433	551	585	670	817	805	1,217	1,155
Patents to top 100 R&D performers	8,399	476	181	189	180	242	281	285	289	199	290	335	360	343	416	453	521	682	671	1,022	984
Massachusetts Institute of Technology	1,109	94	28	40	37	44	59	39	53	43	44	66	51	47	47	35	45	63	63	101	110
University of California	752	59	16	25	22	17	22	25	23	1	2	38	42	48	46	42	54	67	60	81	62
California Institute of Technology	428	29	17	14	15	27	18	16	18	12	26	16	19	16	15	16	23	27	18	56	30
Stanford University	415	3	3	6	7	16	19	18	10	4	11	10	4	16	36	38	33	48	54	43	36
University of Wisconsin	338	15	12	13	8	17	20	25	13	7	28	26	17	13	16	17	17	11	20	27	16
Iowa State University	332	42	11	14	20	15	14	15	12	8	12	12	15	10	14	21	9	15	15	28	30
University of Minnesota	258	15	9	6	4	5	3	5	6	7	6	12	10	5	6	11	16	28	26	40	38
Cornell University	243	11	1	2	3	5	10	10	10	7	11	8	6	10	14	20	13	30	16	22	34
University of Texas	222	0	0	0	0	0	0	1	2	0	1	6	7	5	8	20	25	21	21	51	54
Johns Hopkins University[1]	214	9	7	5	4	10	3	9	10	4	6	9	8	6	10	15	18	18	21	27	15
Purdue University	204	16	10	4	1	13	15	12	6	4	13	15	11	11	14	18	9	4	2	11	15
University of Utah	198	15	8	3	2	5	7	6	12	17	12	7	14	15	9	11	7	12	9	13	14
University of Illinois	189	17	7	8	9	9	14	11	11	6	10	8	7	8	8	10	12	4	9	15	6
Ohio State University	176	38	12	8	3	4	7	9	8	0	3	4	5	8	3	10	5	12	14	13	10
University of Florida	153	0	0	1	1	2	2	0	1	3	7	4	0	6	10	7	10	13	21	33	32
State University of New York	112	0	0	0	0	0	0	0	0	0	1	2	8	2	11	5	11	18	10	25	19
Georgia Institute of Technology	112	6	0	3	5	1	1	2	2	5	3	7	8	3	6	11	9	9	7	8	16
University of Michigan	109	0	0	0	4	0	2	8	2	4	4	1	2	2	1	1	10	6	14	23	25
Harvard University	105	0	0	0	0	0	0	1	2	0	4	3	11	10	7	1	2	9	17	15	23
University of Rochester	100	0	0	0	0	0	4	2	4	0	6	7	8	9	6	2	8	9	11	11	13
University of Southern California	98	0	0	2	3	4	5	6	15	6	7	2	5	1	7	5	5	4	7	8	6
Northwestern University	91	12	0	2	1	0	0	2	7	5	7	1	7	3	2	2	8	10	10	7	5
University of Kentucky	86	8	2	3	6	0	0	1	3	2	5	4	6	6	7	5	7	4	7	6	4
University of Iowa	78	2	0	0	0	0	3	3	2	5	4	4	5	3	4	1	8	8	6	8	12
University of Virginia	78	0	0	1	3	0	3	7	8	6	1	3	8	4	2	1	4	3	4	8	12
University of Pittsburgh	75	0	0	0	0	0	0	0	0	2	6	3	2	5	8	3	8	10	6	11	11
Indiana University	72	24	5	2	0	1	4	4	7	2	2	1	0	3	2	4	0	3	1	6	1
Columbia University	72	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	7	6	15	19	16
University of Missouri	72	0	0	0	2	3	5	0	6	4	1	2	9	5	4	0	3	8	9	5	6
University of Pennsylvania	71	4	1	2	2	1	2	5	5	3	1	1	1	2	4	5	1	2	1	9	19

(continued)

Appendix table 5-29.

Patents awarded to the 100 academic institutions with the greatest R&D volume: 1969-90

(page 2 of 3)

	Total 1969-90	1969-71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
New York University	70	4	2	3	0	2	0	0	0	0	3	1	7	3	4	5	3	5	4	10	14
University of Tennessee	68	8	1	0	1	0	0	0	0	0	0	1	1	0	1	5	8	8	8	12	14
Duke University	62	2	1	1	1	1	0	0	0	0	2	1	3	3	6	4	6	4	9	11	7
Boston University	60	0	0	0	0	0	0	2	1	0	3	2	1	2	2	3	6	9	9	9	11
Kansas State University	58	2	4	3	3	5	3	2	1	3	3	2	2	4	3	2	4	4	3	4	1
Michigan State University	56	0	2	1	0	0	4	0	2	1	2	1	1	3	3	3	10	6	8	2	7
Texas A&M University	55	0	0	0	0	0	0	0	0	1	0	3	3	2	3	8	3	6	9	8	9
Rockefeller University	55	0	0	0	0	0	0	1	0	1	0	3	3	1	3	5	4	9	11	6	8
Baylor University	52	0	0	0	0	1	3	4	1	1	1	3	3	2	2	3	2	7	3	8	8
Yale University	52	0	0	0	0	0	0	1	0	0	0	0	0	2	2	5	3	12	6	11	10
Oregon State University	50	0	0	0	0	0	3	1	1	2	0	4	1	3	4	4	4	6	3	11	3
North Carolina State University	50	0	0	0	0	0	0	0	0	1	0	4	1	0	2	3	4	6	5	10	14
Washington University	49	2	0	0	1	2	1	1	0	0	3	1	0	1	1	3	1	7	6	12	7
University of Alabama	48	1	0	1	0	0	1	4	4	2	3	2	3	1	1	5	3	5	3	3	6
University of Miami	48	0	0	0	0	3	1	0	1	0	2	2	2	0	4	4	3	15	5	5	1
Wayne State University	47	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	5	6	7	16	9
University of Washington	40	0	0	1	0	2	2	1	2	2	0	0	7	2	3	1	2	1	5	3	6
Oklahoma State University	40	10	3	3	1	2	2	2	0	1	1	0	1	0	1	2	2	0	2	3	4
Case Western Reserve University	38	6	2	2	3	0	4	3	0	1	1	1	0	0	1	1	6	3	1	1	2
City University of New York	37	3	1	2	1	1	0	2	1	0	1	5	4	3	2	1	2	1	3	2	2
University of Georgia	37	0	0	0	0	0	0	1	0	0	0	0	0	7	7	5	6	3	0	3	5
University of Arizona	35	0	0	0	0	0	0	0	2	1	2	1	1	2	2	2	2	2	0	8	10
University of Cincinnati	35	0	0	0	1	0	1	0	0	0	0	0	0	0	2	2	1	8	3	8	9
University of Nebraska	35	0	1	0	2	5	0	1	1	0	1	5	4	0	5	1	1	1	4	0	3
Louisiana State University	34	1	0	1	0	0	0	3	2	0	1	2	0	1	1	1	1	3	4	9	4
Yeshiva University	34	2	1	1	0	3	2	0	0	1	2	0	3	0	1	4	1	6	1	5	1
Vanderbilt University	31	0	0	0	0	1	1	0	2	0	1	1	2	1	0	0	5	4	4	4	5
Clemson University	31	0	2	0	0	0	0	1	0	4	1	0	0	0	2	2	1	3	3	6	6
Georgetown University	31	1	2	0	0	0	0	2	0	0	0	2	1	4	5	1	0	4	3	1	5
Carnegie-Mellon University	31	1	0	0	1	1	2	1	4	1	0	0	0	0	3	3	3	1	2	5	3

(continued)

Appendix table 5-29.
Patents awarded to the 100 academic institutions with the greatest R&D volume: 1969-90
(page 3 of 3)

	Total 1969-90	1969-71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
University of Chicago	29	0	0	0	0	2	0	3	1	[illegible]	1	0	2	0	2	0	0	1	6	7	2
Washington State University	28	1	0	1	0	0	0	0	1	2	2	1	3	2	0	2	2	2	1	5	3
University of New Mexico	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	3	9	9
University of Medicine and Dentistry of NJ	27	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	4	7	2	4	7
University of North Carolina	26	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	3	2	2	6	8
University of Oklahoma	25	1	0	0	1	0	0	0	0	0	0	1	1	1	1	3	2	2	6	2	4
University of Kansas	24	3	1	2	0	2	2	0	0	0	2	1	0	2	2	1	0	2	0	1	3
University of Hawaii	22	0	0	0	0	1	0	1	1	1	2	0	1	1	0	2	0	1	3	2	6
Princeton University	21	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	1	12	4
University of Connecticut	20	1	1	0	0	0	0	0	1	0	1	1	0	0	0	1	1	2	1	2	8
Rutgers, The State University	19	0	0	0	0	1	2	1	0	0	0	0	0	0	1	1	0	2	2	7	2
Utah State University	19	0	1	0	1	0	0	1	0	2	2	0	0	0	1	3	2	2	1	1	2
Colorado State University	18	1	3	0	0	1	0	0	0	0	1	0	0	0	0	1	3	4	2	0	2
University of Colorado	18	1	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	1	0	3	9
Tulane University of Louisiana	16	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	3	4	4
Virginia Polytechnic Institute	16	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	7	4
University of Maryland	15	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	3	2	2	1	4
Tufts University	14	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2	7	1
Brown University	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	3	3
Emory University	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	7	3
University of Massachusetts	11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	1	3	3
Auburn University	10	1	0	0	0	0	1	1	1	0	1	1	0	0	0	1	1	0	0	0	2
Florida State University	9	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2	2	1	1	1
Pennsylvania State University	8	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	3
New Mexico State University	6	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	1	2	0	0	0
Woods Hole Oceanographic Institute	6	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Mississippi State University	4	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arizona State University	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
Virginia Commonwealth University	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1

NOTES: Based on 1987 R&D expenditures; not all 100 institutions could be located in the TAF data base.

[1] Includes the Applied Physics Laboratory.

SOURCE: TAF Report, U.S. Universities, U.S. Patent and Trademark Office, July 1991.

See figure 5-15.

Science & Engineering Indicators – 1991

Appendix table 6-1.

Real gross domestic product per capita, for selected countries: 1950, 1955, and 1960-90

	Canada	France	Italy	Japan	South Korea	Sweden	United Kingdom	West Germany
1950 ...	69.5	44.4	32.0	16.7	NA	59.5	61.1	35.8
1955 ...	68.7	46.8	36.3	21.1	9.8	59.5	61.6	47.2
1960 ...	72.1	54.5	45.3	29.8	9.7	67.1	66.7	61.5
1961 ...	72.2	56.4	48.3	33.6	9.9	69.9	67.7	62.9
1962 ...	73.2	57.0	49.2	34.3	9.5	69.9	65.4	62.7
1963 ...	73.7	57.5	50.3	36.6	9.8	71.4	66.0	62.3
1964 ...	74.3	58.4	49.4	39.5	10.1	72.9	66.4	63.3
1965 ...	74.4	58.0	48.4	39.3	10.0	71.7	64.6	63.1
1966 ...	74.5	57.8	48.7	41.2	10.4	69.3	62.6	61.4
1967 ...	74.0	59.0	51.0	44.4	10.6	69.9	62.9	60.1
1968 ...	74.5	59.3	52.4	48.0	11.2	69.9	63.3	61.3
1969 ...	76.2	62.0	54.4	52.4	12.3	71.8	62.9	64.3
1970 ...	78.2	65.9	57.8	57.6	13.2	76.8	65.2	67.9
1971 ...	80.5	67.5	57.5	58.6	14.1	76.0	65.7	68.2
1972 ...	81.2	67.3	56.5	60.3	14.0	74.6	64.7	68.1
1973 ...	83.2	67.7	57.8	61.1	15.2	74.5	67.0	68.4
1974 ...	87.0	70.5	61.6	60.8	16.5	77.9	67.4	69.6
1975 ...	89.8	71.4	60.8	63.1	17.8	81.2	68.4	70.3
1976 ...	90.6	71.4	62.1	62.6	19.1	78.8	68.3	71.7
1977 ...	89.6	70.9	62.0	62.7	20.1	74.6	66.7	71.4
1978 ...	89.1	70.1	61.3	62.6	21.1	72.7	66.4	70.7
1979 ...	90.8	71.4	64.2	64.9	22.1	74.7	67.2	72.9
1980 ...	92.2	73.2	67.7	67.6	21.4	76.8	66.7	74.4
1981 ...	93.6	72.9	67.3	68.9	22.4	76.0	65.4	73.7
1982 ...	92.9	77.1	69.7	73.2	24.2	79.6	68.7	75.7
1983 ...	92.5	75.2	68.3	72.6	25.7	78.8	69.4	75.1
1984 ...	92.1	71.6	66.0	71.0	26.2	77.3	66.4	73.1
1985 ...	93.3	70.8	65.8	72.2	27.0	76.8	66.9	72.8
1986 ...	93.9	70.9	66.3	72.2	29.5	76.9	68.1	72.9
1987 ...	94.2	70.3	66.6	72.9	32.0	76.8	69.2	72.1
1988 ...	94.0	70.5	66.9	74.6	34.1	75.6	69.4	71.8
1989 . .	94.2	71.9	67.8	76.6	35.4	75.6	69.4	72.3
1990 ...	93.9	73.7	69.0	80.7	38.1	75.3	69.8	74.5

NA = not available

NOTES: Output based on Organisation for Economic Cooperation and Development price weights to enable cross-country comparisons. Index: United States = 100.0.

SOURCE: Bureau of Labor Statistics, unpublished tabulations.

See figure 6-1.

Science & Engineering Indicators – 1991

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Appendix table 6-2.

Global production of manufactured products, by selected countries: 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
	Millions of constant 1980 dollars										
Total manufactures											
United States	1,430,747	1,435,326	1,344,149	1,399,916	1,542,762	1,547,177	1,561,688	1,685,110	1,769,769	1,809,062	1,815,580
Japan	796,676	814,486	843,104	895,261	957,703	1,043,767	1,018,609	1,065,679	1,105,732	1,224,983	1,279,649
West Germany	516,797	515,167	520,975	537,401	581,057	636,783	637,013	629,509	651,060	684,896	714,699
France	322,494	313,581	323,348	328,541	342,960	377,864	377,704	379,183	397,797	417,814	424,220
United Kingdom	311,322	284,324	289,596	303,221	331,034	351,554	349,332	371,496	406,626	425,265	430,881
Italy	201,452	202,271	198,030	209,718	227,159	230,267	239,853	247,278	252,985	259,487	263,150
EC-12	1,611,308	1,571,914	1,595,714	1,688,731	1,807,951	1,941,680	1,943,146	1,973,268	2,065,127	2,209,208	2,246,410
Europe	1,842,598	1,805,957	1,833,324	1,934,293	2,067,593	2,219,306	2,232,253	2,261,077	2,354,217	2,501,518	2,531,327
OECD	4,265,013	4,257,110	4,209,318	4,432,237	4,786,448	5,054,011	5,063,814	5,264,009	5,487,951	5,808,597	5,922,903
High-tech manufactures											
United States	286,239	296,433	301,567	320,752	378,567	395,288	421,981	469,626	507,279	534,818	552,231
Japan	130,154	147,610	158,132	183,491	232,905	257,099	268,419	313,916	363,772	422,216	449,442
West Germany	83,262	88,174	91,754	100,589	113,293	130,157	132,259	131,740	138,656	140,793	145,143
France	43,971	45,723	47,452	49,060	52,945	59,272	59,915	61,061	64,448	69,693	71,607
United Kingdom	57,388	60,779	63,409	68,332	79,017	89,242	92,206	102,634	112,624	125,326	130,753
Italy	27,798	27,796	26,231	28,017	31,589	31,461	36,170	38,771	43,067	43,116	42,776
EC-12	249,036	261,304	268,113	294,528	333,749	373,748	385,980	401,511	431,516	445,066	449,214
Europe	272,458	285,925	294,932	322,743	364,216	408,749	424,339	440,300	471,545	481,179	483,123
OECD	708,162	750,462	775,515	849,263	999,522	1,088,661	1,145,111	1,252,843	1,371,023	1,484,959	1,537,395
Other manufactures											
United States	1,144,508	1,138,893	1,042,582	1,079,164	1,164,194	1,151,889	1,139,707	1,215,484	1,262,490	1,274,245	1,263,349
Japan	666,521	666,876	684,972	711,770	724,798	786,669	750,190	751,762	741,960	802,767	830,208
West Germany	433,535	426,993	429,222	436,811	467,764	506,626	504,754	497,769	512,404	544,103	569,556
France	278,524	267,858	275,896	279,481	290,015	318,592	317,789	318,122	333,349	348,121	352,612
United Kingdom	253,934	223,545	226,187	234,889	252,017	262,312	257,127	268,862	294,001	299,938	300,128
Italy	173,654	174,475	171,799	181,701	195,570	198,807	203,683	208,507	209,918	216,370	220,374
EC-12	1,362,272	1,310,610	1,327,601	1,394,203	1,474,201	1,567,932	1,557,166	1,571,757	1,633,611	1,764,142	1,797,196
Europe	1,570,140	1,520,032	1,538,392	1,611,549	1,703,376	1,810,557	1,807,913	1,820,777	1,882,672	2,020,338	2,048,203
OECD	3,556,850	3,506,648	3,433,803	3,582,974	3,786,926	3,965,350	3,918,703	4,011,166	4,116,928	4,323,637	4,385,509

NOTE: Europe includes the 12 countries of the European Community (EC-12) plus Austria, Finland, Norway, Sweden, and Switzerland.

SOURCE: Special tabulations developed by Data Resources, Inc./McGraw-Hill from the Organisation for Economic Cooperation and Development's (OECD's) Industrial Structure Statistics and Series C Trade Data.

Science & Engineering Indicators – 1991

Appendix table 6-3.
Country share of global market for high-tech manufactures, by industry: 1980-90
(page 1 of 3)

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
	Percent										
HIGH-TECH MANUFACTURES											
United States	40.4	39.5	38.9	37.8	37.9	36.3	36.9	37.5	37.0	36.0	35.9
Japan	18.4	19.7	20.4	21.6	23.3	23.6	23.4	25.1	26.5	28.4	29.2
West Germany	11.8	11.7	11.8	11.8	11.3	12.0	11.5	10.5	10.1	9.5	9.4
France	6.2	6.1	6.1	5.8	5.3	5.4	5.2	4.9	4.7	4.7	4.7
United Kingdom	8.1	8.1	8.2	8.0	7.9	8.2	8.1	8.2	8.2	8.4	8.5
Italy	3.9	3.7	3.4	3.3	3.2	2.9	3.2	3.1	3.1	2.9	2.8
EC-12	35.2	34.8	34.6	34.7	33.4	34.3	33.7	32.0	31.5	30.0	29.2
Europe	38.5	38.1	38.0	38.0	36.4	37.5	37.1	35.1	34.4	32.4	31.4
Industrial chemicals											
United States	32.7	33.1	29.8	29.2	28.0	25.8	28.5	31.4	31.2	32.2	32.5
Japan	16.1	14.4	15.3	14.0	14.1	13.4	12.1	13.1	12.7	13.4	14.1
West Germany	16.2	16.9	17.9	19.1	19.5	20.4	20.4	18.5	18.7	18.8	18.4
France	5.0	5.2	5.8	5.5	5.1	5.3	5.3	4.9	5.0	5.1	4.8
United Kingdom	8.8	8.4	9.0	9.4	9.7	10.1	9.5	9.2	9.2	9.3	9.1
Italy	5.1	5.2	4.4	4.4	4.9	4.9	4.3	4.3	4.3	4.3	4.0
EC-12	43.0	44.3	45.8	48.1	49.6	52.0	49.9	46.5	47.2	45.9	44.3
Europe	47.9	49.1	51.2	53.3	54.8	57.6	56.0	52.2	52.8	51.3	50.4
Drugs and medicines											
United States	29.6	29.6	30.3	30.3	30.4	30.0	30.4	31.4	31.4	30.8	29.2
Japan	21.2	21.7	22.1	22.0	21.2	20.7	20.4	19.9	20.1	20.1	20.3
West Germany	13.1	13.1	12.5	12.5	12.7	12.3	12.1	11.4	11.5	11.4	10.9
France	5.6	5.3	4.7	4.4	4.3	4.0	3.8	3.6	3.8	4.0	3.9
United Kingdom	9.3	8.8	9.1	8.8	9.1	9.0	9.2	9.4	9.6	10.0	9.9
Italy	5.5	5.4	5.6	5.4	6.1	6.5	5.8	5.7	6.2	6.3	6.2
EC-12	40.7	40.3	39.1	38.9	39.8	39.8	38.6	38.1	39.0	39.5	39.0
Europe	46.0	45.6	44.6	44.6	45.4	45.9	45.7	45.0	45.7	46.3	47.5
Engines and turbines											
United States	44.2	37.9	35.0	33.0	35.4	34.8	35.4	35.4	35.8	35.2	34.9
Japan	18.4	16.1	17.9	18.8	18.0	17.0	14.9	15.7	15.5	15.8	15.3
West Germany	11.3	9.9	9.0	9.4	10.3	11.2	10.9	11.2	10.7	10.8	11.6
France	6.8	6.1	5.6	5.7	5.9	5.3	4.9	5.1	4.9	4.7	4.9
United Kingdom	6.8	18.3	20.5	18.3	17.1	19.7	21.9	20.9	21.4	22.6	22.3
Italy	4.2	3.7	3.1	4.9	5.5	3.4	3.2	3.1	3.0	2.9	3.0
EC-12	32.7	40.8	41.3	41.3	41.6	42.7	44.3	43.6	43.3	43.8	44.3
Europe	37.2	45.9	47.0	48.1	46.5	48.1	49.6	48.8	48.5	48.9	49.6

(continued)

Appendix table 6-3.

Country share of global market for high-tech manufactures, by industry: 1980-90

(page 2 of 3)

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
						Percent					
Office and computing machinery											
United States	50.0	49.0	49.1	45.2	44.0	39.6	37.8	38.1	37.3	35.6	34.8
Japan	22.0	23.0	24.0	27.2	27.5	30.2	30.8	31.8	33.3	34.6	37.5
West Germany	6.5	7.4	7.0	7.0	7.4	8.3	8.0	7.1	6.6	5.5	5.4
France	3.9	4.6	4.4	4.2	4.3	3.9	3.6	3.2	2.9	2.7	2.6
United Kingdom	6.0	4.7	4.9	5.3	5.8	6.9	6.5	7.4	8.1	8.1	8.1
Italy	2.1	1.9	1.6	1.8	1.7	1.3	3.2	2.9	3.1	2.4	2.3
EC-12	21.9	22.0	21.2	22.6	24.0	25.2	26.5	26.0	25.6	23.3	21.3
Europe	23.9	24.0	23.1	24.4	25.7	27.2	28.6	27.9	27.4	24.5	21.8
Radio, TV, & communication equipment											
United States	36.6	34.8	35.0	34.0	33.8	32.9	32.8	32.3	31.5	29.9	30.6
Japan	26.4	30.5	30.7	32.2	35.5	34.0	33.0	36.5	39.3	42.9	42.0
West Germany	12.0	11.4	11.4	11.1	9.8	11.3	11.6	10.3	9.6	9.5	10.0
France	5.4	5.1	5.2	4.7	4.2	5.1	5.1	4.5	4.1	4.1	4.4
United Kingdom	7.1	6.5	6.5	6.6	6.5	6.4	6.4	6.2	6.0	5.9	6.2
Italy	2.2	1.9	1.9	1.9	1.5	1.4	1.6	1.6	1.5	1.5	1.5
EC-12	32.2	29.9	29.6	29.4	26.7	29.0	29.7	26.8	25.4	24.1	25.2
Europe	35.1	32.7	32.5	31.9	29.0	31.4	32.3	29.2	27.7	25.6	25.9
Aircraft											
United States	57.6	56.4	56.6	55.8	58.7	57.9	59.5	58.7	59.2	56.4	55.9
Japan	2.2	2.4	2.3	2.4	2.5	2.9	2.5	2.8	3.2	3.6	3.6
West Germany	4.8	5.3	6.0	5.4	5.0	5.0	4.4	4.6	4.7	4.6	4.8
France	13.9	13.9	14.2	15.1	13.7	13.0	11.9	12.0	12.9	13.9	13.7
United Kingdom	12.0	12.5	11.7	12.5	11.7	11.8	12.7	13.1	11.2	13.2	13.5
Italy	3.9	3.5	3.6	3.1	2.9	3.4	2.8	3.0	3.0	3.0	3.0
EC-12	36.0	36.9	37.2	37.8	34.7	34.8	33.3	34.3	33.6	36.1	36.1
Europe	37.1	38.1	38.5	39.1	36.2	36.5	35.0	35.9	35.1	37.6	37.7

(continued)

Appendix table 6-3.

Country share of global market for high-tech manufactures, by industry: 1980-90

(page 3 of 3)

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
	Percent										
Scientific instruments											
United States	49.1	49.0	50.5	50.0	50.4	48.4	48.4	50.8	51.5	52.7	53.4
Japan	17.6	19.2	18.1	19.0	19.0	19.7	18.9	18.1	16.2	16.1	15.4
West Germany	11.4	10.8	10.2	9.8	9.8	10.8	11.1	11.1	11.4	10.8	11.1
France	4.4	4.1	4.2	4.4	4.4	5.4	5.5	5.6	5.8	5.9	6.1
United Kingdom	5.4	4.7	5.3	4.9	4.8	5.1	5.3	5.6	5.9	5.8	5.9
Italy	5.5	5.5	5.2	5.1	4.9	4.1	4.1	4.4	4.8	4.5	4.1
EC-12	28.9	27.4	27.1	26.9	26.6	27.5	28.2	28.4	29.7	28.6	28.6
Europe	30.8	29.3	29.0	28.8	28.7	29.9	30.6	30.4	31.6	30.5	30.5

NOTES: Total shipments by OECD countries are used as a proxy for global output. Shares represent each country's shipments as a percentage of OECD shipments. Europe includes the 12 countries of the European Community (EC-12) plus Austria, Finland, Norway, Sweden, and Switzerland.

SOURCE: Special tabulations developed by Data Resources, Inc./McGraw-Hill from the Organisation for Economic Cooperation and Development's (OECD's) Industrial Structure Statistics and Series C Trade Data.

See figures 6-2 and 6-3 and figure O-22 in Overview.

Science & Engineering Indicators – 1991

Appendix table 6-4.

High-tech manufactures' share of total manufacturing output, by country: 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
	Percent										
United States	20.0	20.7	22.4	22.9	24.5	25.5	27.0	27.9	28.7	29.6	30.4
Japan	16.3	18.1	18.8	20.5	24.3	24.6	26.4	29.5	32.9	34.5	35.1
West Germany	16.1	17.1	17.6	18.7	19.5	20.4	20.8	20.9	21.3	20.6	20.3
France	13.6	14.6	14.7	14.9	15.4	15.7	15.9	16.1	16.2	16.7	16.9
United Kingdom	18.4	21.4	21.9	22.5	23.9	25.4	26.4	27.6	27.7	29.5	30.3
Italy	13.8	13.7	13.2	13.4	13.9	13.7	15.1	15.7	17.0	16.6	16.3
EC-12	15.5	16.6	16.8	17.4	18.5	19.2	19.9	20.3	20.9	20.1	20.0
OECD	16.6	17.6	18.4	19.2	20.9	21.5	22.6	23.8	25.0	25.6	26.0

NOTE: EC-12 = 12 countries of the European Community.

SOURCE: Special tabulations developed by Data Resources, Inc./McGraw-Hill from Organisation for Economic Cooperation and Development's (OECD's) Industrial Structure Statistics and Series C Trade Data.

Science & Engineering Indicators – 1991

Appendix table 6-5.
Import share of domestic market, by industry: 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
						Percent					
HIGH-TECH MANUFACTURES											
United States	8.0	8.2	8.0	8.9	10.4	10.8	12.1	13.2	15.1	13.5	13.8
Japan	6.6	6.3	6.3	6.9	6.5	6.5	8.4	8.3	8.8	8.6	9.2
West Germany	25.1	26.7	28.1	27.9	28.4	28.8	31.2	33.9	35.2	37.6	41.2
France	33.2	33.3	34.1	36.6	38.7	40.3	45.1	50.6	53.9	53.5	55.2
United Kingdom	29.1	25.1	27.5	29.4	32.2	33.6	38.8	37.0	39.2	38.5	42.1
Italy	29.3	30.8	34.7	36.9	37.1	44.0	44.5	46.3	47.5	40.5	43.6
Industrial chemicals											
United States	8.0	7.6	8.6	9.4	11.2	12.3	11.7	9.8	9.9	10.8	10.6
Japan	8.6	9.8	11.4	14.3	16.4	17.6	25.7	25.0	26.4	24.5	22.1
Drugs and medicines											
United States	4.8	4.9	4.2	4.9	5.8	6.2	6.9	7.2	8.2	4.9	5.3
Japan	7.8	7.8	8.1	8.3	8.8	9.2	12.9	13.9	14.7	13.6	12.0
Office and computing machinery											
United States	3.8	4.4	5.2	8.0	9.8	10.4	13.6	16.8	20.3	15.5	16.4
Japan	1.9	2.0	2.0	1.6	1.8	2.0	2.3	3.0	3.9	5.3	6.2
Radio, TV, & communication equipment											
United States	5.0	5.0	5.2	5.7	7.1	5.3	5.5	6.5	8.2	9.1	8.8
Japan	1.4	1.3	1.2	1.4	1.6	1.3	1.9	1.9	2.3	2.4	2.7
Aircraft											
United States	5.6	6.6	5.6	4.6	5.3	6.1	6.7	6.4	6.7	7.1	7.7
Japan	34.4	39.7	30.8	47.1	34.2	40.8	49.9	43.7	41.4	32.1	42.2
Scientific instruments											
United States	13.1	13.6	12.0	13.0	14.9	15.9	18.4	18.6	19.0	18.7	17.5
Japan	19.9	18.1	19.8	23.1	27.0	27.0	36.9	44.0	62.4	69.0	73.8

SOURCE: Special tabulations developed by Data Resources, Inc./McGraw-Hill from Organisation for Economic Cooperation and Development's Industrial Structure Statistics and Series C Trade Data

See figures 6-4 and 6-5.

Science & Engineering Indicators – 1991

Appendix table 6-6.

U.S. share of foreign markets for high-tech manufactures: 1980-90

	1980	1981	1982	1983	1984	1985	1986	1987	1988 (est.)	1989 (est.)	1990 (est.)
						Percent					
High-tech manufactures	10.0	9.6	8.7	8.1	7.8	7.6	8.1	8.9	9.9	9.2	9.7
Industrial chemicals	5.9	5.7	5.2	4.7	4.9	4.5	5.2	5.6	5.8	6.7	6.2
Drugs and medicines	4.6	4.6	4.3	4.3	4.3	4.1	4.4	4.2	4.6	3.6	3.5
Engines and turbines	39.6	32.3	31.8	30.9	31.0	33.7	37.4	40.0	44.1	39.7	41.0
Office and computing machinery	10.8	10.8	10.1	9.7	9.7	8.9	9.0	10.6	12.3	9.4	9.5
Radio, TV, & comm. equipment	1.7	1.4	2.6	2.6	2.6	2.0	2.3	2.5	2.9	3.0	3.4
Aircraft	26.3	27.2	22.0	22.4	20.4	23.1	23.6	24.6	25.7	25.0	28.9
Scientific instruments	18.5	18.6	17.7	16.7	16.7	15.1	16.0	17.8	19.8	22.4	23.1
Other manufactures	4.8	4.9	4.2	3.7	3.7	3.3	3.3	3.7	4.6	4.7	5.1

NOTES: Foreign market size is calculated by subtracting U.S. apparent consumption of high-tech products from total Organisation for Economic Cooperation and Development shipments of same. The concept of foreign market share differs from export market share by adding the home market shipments of non-U.S. producers to the denominator. Foreign market share provides a measure of U.S. competitiveness against foreign producers in their home markets and export markets.

SOURCE: Data Resources, Inc./McGraw-Hill, special tabulations.

See figure 6-6.

Science & Engineering Indicators – 1991

Appendix table 6-7.
Export market shares, by industry and country: 1980-88
(page 1 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
					Percent				
ALL MANUFACTURING INDUSTRIES									
United States	16.2	15.7	13.6	12.2	11.6	10.6	10.2	11.2	13.1
Japan	10.8	11.7	11.4	12.1	13.1	12.9	12.7	12.4	12.5
West Germany	17.3	17.8	18.5	17.9	17.9	18.4	17.8	17.2	16.8
France	10.2	10.2	10.1	10.2	10.0	9.8	9.3	9.3	9.4
United Kingdom	8.7	7.5	7.9	7.7	7.8	8.1	9.0	9.2	8.8
Italy	7.0	7.3	7.6	7.6	7.4	7.7	7.6	7.5	7.6
EC-12	59.0	58.4	60.3	60.4	59.8	60.8	61.3	60.8	60.1
High-tech manufactures									
United States	26.9	25.9	23.3	22.0	20.9	20.1	20.1	21.8	23.4
Japan	9.7	10.1	9.9	11.0	12.1	11.6	12.5	13.7	15.2
West Germany	16.1	17.0	18.1	17.3	17.5	17.1	15.5	14.4	13.5
France	9.3	9.6	9.9	9.8	10.2	10.3	9.3	9.6	9.2
United Kingdom	12.6	10.9	11.7	11.4	12.0	13.3	14.6	13.5	12.0
Italy	3.6	4.3	4.6	5.0	4.6	4.7	4.4	4.4	4.2
EC-12	52.3	52.4	55.6	55.5	56.1	57.3	56.4	54.0	52.2
Industrial chemicals									
United States	18.0	16.9	15.4	13.1	13.1	11.8	12.0	13.1	13.4
Japan	6.7	6.0	6.2	6.0	5.7	5.9	6.3	7.2	6.8
West Germany	19.1	20.1	20.9	20.6	21.4	21.1	19.3	18.7	17.5
France	11.9	12.0	9.8	12.0	12.3	13.4	13.0	13.3	12.3
United Kingdom	10.2	9.6	10.6	10.3	10.6	11.3	13.0	13.0	12.0
Italy	3.6	4.5	5.6	6.5	5.6	5.6	4.2	4.6	5.0
EC-12	63.4	64.7	66.1	69.0	69.5	70.1	69.2	67.1	68.3
Drugs and medicines									
United States	15.6	14.9	12.9	14.0	13.4	12.3	12.6	12.2	13.5
Japan	2.3	2.3	2.0	2.3	2.3	2.3	2.3	2.3	2.4
West Germany	17.5	18.0	16.2	17.4	18.1	18.3	17.4	17.2	17.0
France	11.6	11.5	19.8	11.8	11.6	11.6	11.0	10.9	10.8
United Kingdom	13.4	12.9	12.6	13.2	13.4	13.7	14.9	14.5	13.8
Italy	5.3	5.6	5.1	5.6	5.9	6.2	5.6	5.3	5.5
EC-12	63.4	63.2	68.0	64.3	65.8	66.5	66.1	66.3	65.8
Engines and turbines									
United States	26.7	25.2	23.3	21.0	19.9	19.0	17.6	18.2	20.1
Japan	10.9	12.2	11.3	12.3	14.2	13.5	13.9	14.2	13.7
West Germany	16.6	15.8	17.3	17.6	17.7	17.9	17.6	17.3	16.2
France	8.5	8.6	8.4	8.7	8.8	9.3	9.0	9.3	9.4
United Kingdom	16.3	15.9	16.0	13.4	12.8	13.5	15.2	14.0	14.9
Italy	4.6	4.9	4.9	5.8	5.0	4.2	5.0	5.0	4.2
EC-12	51.7	51.3	53.4	52.1	50.7	52.5	53.2	51.9	50.9

(continued)

Appendix table 6-7.
Export market shares, by industry and country: 1980-88
(page 2 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Percent								
Office and computing machinery									
United States	42.3	41.4	38.1	35.7	33.6	28.8	27.1	28.5	31.8
Japan	6.3	7.8	9.2	10.7	10.8	11.2	13.5	15.8	20.0
West Germany	12.1	13.4	13.4	12.3	11.3	11.5	11.1	9.0	7.6
France	9.9	10.6	8.2	8.4	9.2	9.0	7.9	8.0	7.2
United Kingdom	12.9	10.0	11.8	12.9	15.6	18.2	17.5	16.9	12.0
Italy	2.8	3.0	3.6	3.4	3.2	4.5	4.6	4.0	4.0
EC-12	46.7	46.7	48.8	49.7	52.1	56.4	55.7	52.5	45.7
Radio, TV, and communication equipment									
United States	24.3	22.5	33.5	30.5	25.6	21.7	23.1	23.7	23.6
Japan	26.8	29.6	25.8	30.0	33.4	29.9	31.0	32.0	34.4
West Germany	14.1	14.2	11.5	11.2	11.2	11.9	10.3	9.6	10.8
France	8.7	9.4	7.2	6.8	6.6	8.0	7.5	8.1	7.7
United Kingdom	7.9	6.7	7.3	6.8	7.7	10.2	10.1	9.0	8.8
Italy	3.8	4.1	3.7	3.6	3.4	4.1	3.8	4.3	3.2
EC-12	44.1	42.1	36.7	35.3	35.8	41.6	39.4	37.5	36.4
Aircraft									
United States	53.0	51.0	38.7	41.1	34.6	40.8	43.3	50.0	44.8
Japan	0.4	0.4	0.6	0.6	0.5	0.5	0.5	0.7	0.7
West Germany	10.7	15.0	21.1	17.3	20.5	16.8	11.0	11.8	13.2
France	6.7	8.7	12.0	11.7	15.0	11.9	9.2	11.0	12.9
United Kingdom	18.3	10.5	12.8	14.7	15.0	15.1	19.7	9.7	10.7
Italy	1.8	4.5	4.7	4.7	5.4	5.0	4.1	4.0	4.3
EC-12	42.0	43.3	55.1	53.0	59.1	51.7	47.0	40.3	47.6
Scientific instruments									
United States	21.4	20.6	19.3	17.0	15.8	13.9	13.5	13.8	14.9
Japan	17.7	18.5	17.8	19.3	20.0	19.9	20.0	19.8	20.0
West Germany	16.4	16.9	17.7	17.1	17.6	18.6	18.1	17.7	17.6
France	7.6	7.4	7.5	7.7	7.9	8.0	7.0	7.3	7.4
United Kingdom	9.3	8.8	9.7	9.8	10.2	10.7	11.8	11.7	11.6
Italy	3.3	3.3	3.3	3.5	3.6	3.8	3.9	4.0	3.9
EC-12	45.6	45.6	48.0	48.4	49.5	51.2	51.6	51.4	51.5
Other manufactures									
United States	14.1	13.6	11.5	10.0	9.4	8.3	7.6	8.3	10.0
Japan	11.0	12.0	11.7	12.3	13.3	13.2	12.7	12.1	11.7
West Germany	17.5	17.9	18.6	18.0	17.9	18.8	18.4	18.0	17.8
France	10.4	10.3	10.2	10.2	9.9	9.7	9.3	9.2	9.4
United Kingdom	7.9	6.8	7.0	6.9	6.8	6.8	7.5	8.0	7.9
Italy	7.7	8.0	8.2	8.2	8.1	8.4	8.4	8.3	8.6
EC-12	60.3	59.6	61.3	61.5	60.6	61.7	62.5	62.7	62.4

NOTE: EC-12 = 12 countries of the European Community.

SOURCE: Special tabulations developed by Data Resources, Inc./McGraw-Hill from Organisation for Economic Cooperation and Development's Industrial Structure Statistics and Series C Trade Data.

See figure 6-7.

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Appendix table 6-8.

Trade balances for high-tech industries, by country: 1980-88

(page 1 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Millions of constant 1980 dollars								
High-tech manufactures									
United States	23,698	23,643	20,640	17,512	10,881	12,210	9,187	10,392	11,855
Japan	8,022	9,267	8,943	10,378	14,193	15,127	15,622	20,114	26,627
West Germany	7,941	8,914	10,663	9,462	12,670	11,244	6,002	3,151	1,807
France	1,213	2,690	3,191	2,893	5,817	5,862	563	357	- 1,298
United Kingdom	6,092	5,377	5,949	4,328	4,093	8,078	11,692	9,371	588
Italy	- 3,059	- 1,422	- 1,018	- 389	- 1,418	- 2,398	- 5,695	- 7,088	- 2,369
Industrial chemicals									
United States	3,073	2,926	2,420	1,459	1,080	485	1,005	2,041	2,572
Japan	267	- 90	- 557	- 1,141	- 2,092	- 1,921	- 3,303	- 3,516	- 4,205
West Germany	2,933	3,243	3,468	4,129	5,072	4,617	3,219	2,812	2,976
France	- 436	454	- 280	1,210	1,495	2,018	1,024	1,073	944
United Kingdom	1,372	1,022	1,204	1,218	1,224	1,788	2,379	2,223	2,108
Italy	- 1,460	- 883	- 583	- 232	- 624	- 1,046	- 2,856	- 2,710	- 3,122
Drugs and medicines									
United States	1,217	1,217	1,221	1,110	914	740	806	570	567
Japan	- 779	- 803	- 914	- 929	- 986	- 1,002	- 1,730	- 1,954	- 2,240
West Germany	981	1,188	1,180	1,161	1,265	1,289	1,170	1,115	1,165
France	796	821	2,257	857	886	895	816	739	575
United Kingdom	1,217	1,123	1,185	1,065	1,125	1,247	1,550	1,410	1,304
Italy	36	92	82	- 16	- 15	- 75	- 450	- 513	746
Engines and turbines									
United States	4,566	4,256	4,102	2,717	1,401	288	- 557	- 590	94
Japan	2,824	3,463	3,086	3,268	3,928	3,880	4,084	4,318	4,533
West Germany	3,391	3,256	3,722	3,418	3,769	3,680	3,266	3,151	2,917
France	475	456	- 2	71	358	378	- 126	- 355	548
United Kingdom	2,959	2,613	2,517	1,567	1,547	1,754	2,015	1,436	1,614
Italy	153	356	399	737	461	126	301	318	234
Office and computing machinery									
United States	2,517	2,864	2,701	2,847	2,867	4,084	1,952	935	819
Japan	279	487	742	1,675	2,722	4,233	7,012	10,697	16,263
West Germany	- 78	9	0	- 382	- 470	- 1,137	- 1,954	- 3,631	- 5,402
France	139	172	- 315	- 470	422	300	- 988	- 996	- 2,559
United Kingdom	138	- 85	- 121	- 206	104	2,864	3,056	3,669	- 4,105
Italy	- 263	- 211	- 223	- 217	- 202	- 121	- 249	- 908	- 1,458
Radio, TV, & comm. equipment									
United States	- 1,554	- 1,835	- 386	- 646	- 2,240	- 1,411	- 1,004	- 1,383	- 2,420
Japan	1,594	1,843	2,084	3,058	4,973	4,170	4,459	5,522	7,599
West Germany	- 596	- 468	- 406	- 450	- 612	- 880	- 1,225	- 1,147	- 947
France	- 192	- 36	- 122	- 93	- 145	- 104	- 204	- 224	- 601
United Kingdom	- 177	- 321	- 346	- 603	- 864	- 699	- 538	- 925	- 1,163
Italy	- 408	- 216	- 273	- 245	- 512	- 532	- 801	- 1,058	- 509
Aircraft									
United States	10,518	10,943	7,463	7,892	5,925	7,887	7,841	9,785	10,570
Japan	- 913	- 1,204	- 662	- 1,402	- 874	- 1,582	- 2,214	- 1,987	- 2,144
West Germany	- 476	- 777	- 69	- 1,040	439	- 156	- 1,467	- 1,586	- 1,501
France	763	1,042	2,067	1,664	2,817	2,365	1,248	1,634	1,424
United Kingdom	422	1,218	1,609	1,664	1,430	1,236	3,083	1,471	843
Italy	- 224	237	452	394	273	148	- 96	- 97	9

(continued)

Appendix table 6-8.

Trade balances for high-tech industries, by country: 1980-88

(page 2 of 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Millions of constant 1980 dollars								
Scientific instruments									
United States	3,362	3,272	3,119	2,135	933	138	- 857	- 966	- 347
Japan	4,750	5,572	5,163	5,848	6,523	7,348	7,313	7,035	6,824
West Germany	1,785	2,465	2,770	2,626	3,208	3,831	2,992	2,437	2,600
France	- 333	- 218	- 416	- 348	- 14	9	- 1,205	- 1,516	- 1,628
United Kingdom	162	- 193	- 100	- 379	- 473	- 112	147	87	- 10
Italy	- 891	- 796	- 871	- 809	- 801	- 895	- 1,544	- 2,119	- 625
Other manufactures									
United States	- 12,734	- 14,989	- 26,275	- 50,788	- 90,043	- 113,885	- 138,294	- 140,655	- 125,126
Japan	53,923	65,121	60,801	66,550	79,944	84,706	65,097	45,136	25,811
West Germany	33,511	49,165	53,673	40,922	48,348	56,764	37,002	30,691	33,553
France	10,343	16,749	7,916	8,629	12,069	7,008	- 14,145	- 23,823	- 25,183
United Kingdom	- 4,667	- 12,189	- 16,247	- 25,911	- 31,699	- 32,064	- 34,316	- 36,171	- 47,151
Italy	13,830	25,277	24,776	25,140	24,194	24,969	16,802	7,299	9,401

SOURCE: Special tabulations developed by Data Resources, Inc./McGraw-Hill from Organisation for Economic Cooperation and Development's Industrial Structure Statistics and Series C Trade Data.

See figure 6-8 and figure O-23 in Overview.

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Appendix table 6-9.

U.S. receipts and payments of royalties and license fees generated from the exchange and use of industrial processes with unafilliated foreign residents: 1987-89

	Receipts			Payments			Balance		
	1987	1988	1989	1987	1988	1989	1987	1988	1989
	Millions of dollars								
ALL COUNTRIES	1,592	1,871	1,902	436	449	597	1,156	1,422	1,305
Canada	87	61	56	9	11	13	78	50	43
Europe	446	524	523	320	330	449	126	194	74
Western Europe	439	492	512	320	330	448	119	162	64
European Community	353	416	372	248	277	392	105	139	-20
France	73	81	51	33	37	50	40	44	1
West Germany	79	74	76	100	112	135	-21	-38	-59
Italy	57	74	67	25	20	32	32	54	35
United Kingdom	60	68	74	72	80	61	-12	-12	13
Other	84	119	104	18	28	114	66	91	-10
Other Western Europe	86	76	140	72	53	56	14	23	84
Eastern Europe	7	32	11	*	*	1	7	32	10
South and Central America	63	48	49	5	*	*	58	48	49
Brazil	19	7	11	*	*	*	19	7	11
Mexico	14	13	17	3	*	*	11	13	17
All other	30	28	21	2	NA	NA	28	28	21
Africa	D	23	24	*	4	*	0	19	24
Middle East	D	18	18	2	3	4	-2	15	14
Asia and Pacific	936	1,184	1,221	95	98	128	841	1,086	1,093
Hong Kong	4	6	8	1	*	*	3	6	8
India	18	40	26	*	*	*	18	40	26
Indonesia	5	4	8	0	*	0	5	4	8
Japan	723	884	889	88	95	113	635	789	776
South Korea	34	104	166	*	*	1	34	104	165
The Philippines	3	4	3	0	*	1	3	4	2
Singapore	30	13	3	*	0	0	30	13	3
Taiwan	21	46	22	*	*	4	21	46	18
All other	98	83	96	6	3	9	92	80	87
All other	60	13	11	5	3	3	55	10	8

NA = not available

* = less than $500,000

D = withheld to avoid disclosing operations of individual companies

NOTE: Industrial processes include patents and other proprietary inventions and technology.

SOURCE: Bureau of Economic Analysis, *Survey of Current Business*, Vol. 70, No. 9 (September 1990): pp. 45-47.

See figure 6-9. *Science & Engineering Indicators – 1991*

Appendix table 6-10.

U.S. receipts and payments of royalties and fees associated with unaffiliated foreign residents: 1972-89

(page 1 of 2)

	All countries	Canada	France	Japan	United Kingdom	West Germany	Other countries
	Millions of current dollars						
Receipts							
1972	655	38	42	240	63	56	216
1973	712	32	43	273	75	63	226
1974	751	38	46	249	71	78	269
1975	757	38	47	219	79	81	293
1976	822	45	57	246	72	83	319
1977	1,037	42	48	275	82	92	498
1978	1,180	61	47	343	93	119	517
1979	1,204	43	54	343	102	109	553
1980	1,305	68	144	403	113	145	432
1981	1,490	69	133	423	119	101	645
1982	1,669	71	119	502	122	105	750
1983	1,679	79	136	523	134	136	671
1984	1,709	84	105	549	133	127	711
1985	1,899	101	122	606	126	112	832
1986	1,842	145	105	632	113	117	730
1987	2,171	155	95	854	111	135	821
1988	2,522	107	96	1,016	127	126	1,050
1989	2,639	127	79	1,026	147	144	1,116
Payments							
1972	139	6	13	6	44	29	41
1973	176	6	16	13	53	37	51
1974	186	7	14	12	67	34	52
1975	186	9	15	9	76	32	45
1976	189	9	14	13	77	34	42
1977	262	8	14	16	72	31	121
1978	277	10	16	15	84	27	125
1979	309	16	17	15	93	40	128
1980	297	18	31	20	96	61	71
1981	289	13	30	37	99	43	67
1982	292	10	22	31	94	35	100
1983	318	10	29	53	90	35	101
1984	359	11	32	63	85	59	109
1985	425	10	25	66	123	47	154
1986	460	10	31	114	76	93	136
1987	520	18	38	104	96	109	155
1988	1,086	225	51	110	145	125	430
1989	871	118	55	126	190	153	229
Balance							
1972	516	32	29	234	19	27	175
1973	536	26	27	260	22	26	175
1974	565	31	32	237	4	44	217
1975	571	29	32	210	3	49	248
1976	633	36	43	233	-5	49	272
1977	775	34	34	259	10	61	377
1978	903	51	31	328	9	92	392
1979	895	27	37	328	9	69	425

(continued)

Appendix table 6-10.

U.S. receipts and payments of royalties and fees associated with unaffiliated foreign residents: 1972-89

(page 2 of 2)

	All countries	Canada	France	Japan	United Kingdom	West Germany	Other countries
	Millions of current dollars						
1980	1,008	50	113	383	17	84	361
1981	1,201	56	103	386	20	58	578
1982	1,377	61	97	471	28	70	650
1983	1,361	69	107	470	44	101	570
1984	1,350	73	73	486	48	68	602
1985	1,474	91	97	540	3	65	678
1986	1,382	134	74	519	36	27	592
1987	1,648	137	57	750	14	27	663
1988	1,436	-118	45	906	-18	1	484
1989	1,768	9	24	900	-43	-9	835

NOTE: Data do not include transactions involving services.

SOURCE: Bureau of Economic Analysis, unpublished tabulations.

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Appendix table 6-11.

Japanese purchases of technological know-how through new sales agreements with selected major countries: 1984-88

	United States	Canada	United Kingdom	West Germany	France	Total
			Number of agreements			
1984	591	42	48	130	52	863
1985	716	23	134	102	38	1,013
1986	771	11	50	148	42	1,022
1987	483	11	55	101	34	684
1988	1,011	27	57	91	57	1,243
			Value of agreements (million yen)			
1984	23,660	295	2,123	1,631	603	28,312
1985	23,837	456	2,149	1,856	858	29,156
1986	24,210	161	1,283	2,955	1,125	29,734
1987	29,049	285	1,527	1,911	15,132	47,904
1988	32,893	756	1,101	1,866	7,046	43,662

SOURCES: Management and Coordination Agency, Statistics Bureau, Government of Japan, unpublished statistics; updates provided by Division of International Programs, Tokyo Office, National Science Foundation.

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Appendix table 6-12.

Japanese sales of technological know-how through new sales agreements with selected major countries: 1984-88

	United States	Canada	United Kingdom	West Germany	France	Total
			Number of agreements			
1984	197	41	47	37	39	361
1985	261	10	42	61	41	415
1986	238	20	45	45	48	396
1987	244	7	50	60	53	414
1988	301	18	51	59	24	453
			Value of agreements (million yen)			
1984	12,092	646	1,971	467	1,681	16,857
1985	7,235	176	1,767	6,693	1,346	17,217
1986	8,018	311	1,667	2,175	1,126	13,297
1987	10,237	123	2,366	1,834	1,671	16,231
1988	5,500	325	1,510	1,877	530	9,742

SOURCES: Management and Coordination Agency, Statistics Bureau, Government of Japan, unpublished statistics; updates provided by Division of International Programs, Tokyo Office, National Science Foundation.

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Appendix table 6-13.
National R&D expenditures, by sector of performance and source of funds: 1975 and 1988

	France	West Germany	Japan	United Kingdom	Sweden	Italy	United States
	Percentage distribution						
SECTOR OF PERFORMANCE							
1975							
Total	100	100	100	100	100	100	100
Government	23	17	12	26	8	22	15
Industry	60	63	57	62	69	56	69
Higher education	16	20	28	8	23	22	13
Other[1]	1	*	3	3	NA	NA	4
1988[2]							
Total	100	100	100	100	100	100	100
Government	24	13	9	15	4	22	14
Industry	60	72	68	67	67	58	73
Higher education	15	14	19	14	29	20	10
Other[1]	1	NA	4	4	*	NA	3
	Percentage change						
Government	+1	-4	-3	-11	-4	0	-1
Industry	0	+9	+11	+5	-2	+2	+4
Higher education	-1	-6	-9	-6	+6	-2	-3
Other[1]	0	*	+1	+1	*	NA	-1
	Percentage distribution						
SOURCE OF FUNDS							
1975							
Total	100	100	100	100	100	100	100
Government	54	47	29	52	39	43	51
Industry	39	50	55	41	57	51	45
Higher education	1	NA	15	1	1	1	2
Other[3]	6	2	1	7	3	5	2
1988[4]							
Total	100	100	100	100	100	100	100
Government	51	36	20	39	38	54	46
Industry	43	63	70	50	60	42	50
Higher education	NA	NA	9	*	*	NA	3
Other[3]	6	1	1	11	1	4	1
	Percentage change						
Government	-3	-11	-9	-13	-1	+11	-5
Industry	+4	+13	+15	+9	+3	-9	+5
Higher education	-1	—	-6	-1	-1	-1	+1
Other[3]	0	-1	0	+4	-2	-1	-1

* = less than 0.5 percent; NA = not available; — = unknown

NOTE: Percentages may not total 100 because of rounding.

[1] Private nonprofit institutions.

[2] French and Japanese figures for 1988 are National Science Foundation (NSF) estimates; United Kingdom and Swedish data are for 1987. Italian figures are for 1986.

[3] Private nonprofit institutions and funds from abroad.

[4] French and Japanese figures for 1988 are NSF estimates; United Kingdom, Swedish, and Italian data are for 1987.

SOURCES: NSF; Organisation for Economic Cooperation and Development; and national sources.

See figures 6-10 and 6-11. *Science & Engineering Indicators – 1991*

Appendix table 6-14.

Percentage of national R&D financed by industry, by country: 1970-88

	France	West Germany	Japan	United Kingdom	Sweden	Italy	United States
1970	37	53	55	NA	NA	51	40
1971	37	52	55	NA	56	52	41
1972	37	49	55	44	NA	52	41
1973	38	49	55	NA	54	49	43
1974	38	48	55	NA	NA	51	45
1975	39	50	55	41	57	51	45
1976	42	51	55	NA	NA	50	45
1977	41	53	56	NA	59	47	46
1978	42	52	58	44	NA	50	47
1979	43	55	59	NA	60	55	47
1980	44	56	61	NA	NA	52	49
1981	41	56	62	41	57	50	50
1982	42	57	64	NA	NA	49	51
1983	42	59	65	42	59	45	50
1984	41	59	67	NA	NA	44	50
1985	42	60	69	47	61	45	49
1986	41	61	69	50	NA	40	48
1987	42	63	69	50	60	42	48
1988	43	63	70	NA	NA	41	50

NA = not available

NOTES: Data for 1988 are national estimates; 1988 figure for France is a National Science Foundation (NSF) estimate.

SOURCES: NSF; Organisation for Economic Cooperation and Development; and national sources.

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Appendix table 6-15.
Industrial R&D expenditures, by source of funds: 1953-91

	Total R&D		Federal		Company[1]	
	Current dollars	Constant 1982 dollars[2]	Current dollars	Constant 1982 dollars[2]	Current dollars	Constant 1982 dollars[2]
	Millions of dollars					
1953	3,630	14,021	1,430	5,523	2,200	8,497
1954	4,070	15,475	1,750	6,654	2,320	8,821
1955	4,640	17,090	2,180	8,029	2,460	9,061
1956	6,605	23,530	3,328	11,856	3,277	11,674
1957	7,731	26,585	4,335	14,907	3,396	11,678
1958	8,389	28,274	4,759	16,040	3,630	12,235
1959	9,618	31,597	5,635	18,512	3,983	13,085
1960	10,509	33,955	6,081	19,648	4,428	14,307
1961	10,908	34,917	6,240	19,974	4,668	14,942
1962	11,464	35,892	6,434	20,144	5,029	15,745
1963	12,630	38,981	7,270	22,438	5,360	16,543
1964	13,512	41,032	7,720	23,444	5,792	17,589
1965	14,185	41,992	7,740	22,913	6,445	19,079
1966	15,548	44,474	8,332	23,833	7,216	20,641
1967	16,385	45,590	8,365	23,275	8,020	22,315
1968	17,429	46,194	8,560	22,688	8,869	23,506
1969	18,308	46,023	8,451	21,244	9,857	24,779
1970	18,067	42,986	7,779	18,508	10,288	24,478
1971	18,320	41,280	7,666	17,274	10,654	24,006
1972	19,552	42,056	8,017	17,245	11,535	24,812
1973	21,249	42,893	8,145	16,441	13,104	26,451
1974	22,887	42,415	8,220	15,234	14,667	27,181
1975	24,187	40,781	8,605	14,509	15,582	26,272
1976	26,997	42,805	9,561	15,159	17,436	27,645
1977	29,825	44,330	10,485	15,584	19,340	28,746
1978	33,304	46,115	11,189	15,493	22,115	30,622
1979	38,226	48,652	12,518	15,932	25,708	32,720
1980	44,505	51,919	14,029	16,366	30,476	35,553
1981	51,810	55,140	16,382	17,435	35,428	37,705
1982	58,650	58,650	18,545	18,545	40,105	40,105
1983	65,268	62,842	20,680	19,911	44,588	42,931
1984	74,800	69,433	23,396	21,717	51,404	47,716
1985	84,239	75,925	27,196	24,512	57,043	51,413
1986	87,823	77,160	27,891	24,504	59,932	52,655
1987	92,155	78,477	30,752	26,188	61,403	52,289
1988	97,889	80,680	32,306	26,627	65,583	54,053
1989	101,599	80,436	31,366	24,833	70,233	55,604
1990 (est.)	104,800	79,629	31,800	24,162	73,000	55,467
1991 (est.)	109,150	79,434	33,000	24,016	76,150	55,418

[1] Company funds include funds for industrial R&D work performed within company facilities from all sources except the Federal Government. The sources of funds may comprise those from outside organizations such as research institutions, universities and colleges, other nonprofit organizations, other companies, and state governments, as well as companies' own. Company-financed R&D not performed within the company is excluded.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Research and Development in Industry: 1989,* NSF 91-302 (Washington, DC: NSF, 1991).

See figure 6-12.

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Appendix table 6-16.

Total expenditures for industrial R&D (financed by company, Federal, and other funds), by industry and size of company: 1979-89

(page 1 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of current dollars										
TOTAL	All	38,226	44,505	51,810	58,650	65,268	74,800	84,239	87,823	92,155	97,889	101,599
High-technology manufacturing industries	28,36,372,376,38	22,408	26,038	31,536	35,908	39,538	45,165	50,216	49,976	55,163	58,340	59,722
Other manufacturing industries	Other mfg SICs	14,278	16,652	18,368	20,270	22,393	24,730	27,309	30,401	29,148	31,436	33,604
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	1,540	1,815	1,906	2,472	3,337	4,905	6,714	7,446	7,844	8,113	8,273
Distribution by manufacturing industry												
Chemicals and allied products	28	4,038	4,636	5,625	6,604	7,185	7,927	8,540	8,843	9,635	10,772	11,537
Industrial chemicals	281-82,286	1,962	2,197	2,802	3,206	3,214	3,240	3,498	3,552	3,716	3,959	4,056
Drugs and medicines	283	1,517	1,777	D	D	D	D	D	3,658	D	4,746	D
Other chemicals	284-85,287-89	559	662	D	D	D	D	D	1,633	D	2,067	D
Petroleum refining and extraction	13,29	1,262	1,552	D	D	D	D	D	D	1,897	1,944	2,066
Rubber products	30	577	656	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	32	356	406	D	D	D	D	D	950	995	D	D
Primary metals	33	634	728	878	987	1,085	D	D	D	730	663	768
Fabricated metal products	34	455	550	624	625	701	842	829	895	783	829	788
Machinery	35	4,825	5,901	6,818	8,078	9,027	10,504	12,216	D	D	D	D
Office, computing, and accounting machines	357	3,214	3,962	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	351-56,358-59	1,611	1,939	D	D	D	D	D	2,396	2,428	2,719	2,789
Electrical equipment	36	7,824	9,175	10,329	10,923	12,681	13,778	14,432	14,980	15,848	16,242	16,768
Radio and TV receiving equipment	365	245	556	D	D	D	D	D	133	139	139	85
Communication equipment	366	3,635	4,024	4,758	5,839	7,298	8,685	9,397	9,669	10,184	10,296	10,508
Electronic components	367	1,169	1,547	1,573	1,740	2,169	2,831	3,385	D	4,286	4,607	4,884
Other electrical equipment	361-64,369	2,775	3,048	D	D	D	D	D	D	1,239	1,200	1,291
Transportation equipment	37	12,709	14,315	D	D	D	D	D	31,275	34,246	36,338	36,863
Motor vehicles and motor vehicles equipment	371	4,509	4,955	4,806	4,797	5,318	6,057	6,984	D	D	D	D
Other transportation equipment	373-75,379	159	162	D	D	D	D	D	D	D	D	D
Aircraft and missiles	372,376	8,041	9,198	11,968	14,451	15,406	18,858	22,231	21,050	24,458	25,900	25,654
Professional and scientific instruments	38	2,505	3,029	3,614	3,930	4,266	4,602	5,013	5,103	5,222	5 426	5,763
Scientific and mechanical measuring instruments	381-82	950	1,352	D	D	D	D	D	D	D	1,734	1,868
Optical, surgical, photographic, and other instruments	383-87	1,555	1,677	D	D	D	D	D	D	D	3,692	3,895
Distribution by size of company[1]												
Less than 500		1,764	2,065	2,305	2,934	4,422	4,402	5,866	7,071	7,163	S	7,446
500 - 999							1,439	1,648	1,902	1,725	1,656	1,718
1,000 - 4,999		2,483	2,701	3,148	3,864	4,178	5,520	6,240	7,472	7,262	7,598	7,843
5,000 - 9,999		1,691	2,028	2,988	2,751	2,798	3,251	4,022	4,251	4,501	5,236	5,475
10,000 - 24,999		5,191	6,017	6,762	7,943	9,499	11,351	11,109	10,493	12,043	11,473	10,432
25,000 or more		27,097	31,693	36,607	41,156	44,372	48,837	55,354	56,991	59,461	64,678	68,685

(continued)

Appendix table 6-16.
Total expenditures for industrial R&D (financed by company, Federal, and other funds), by industry and size of company: 1979-89
(page 2 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of constant 1982 dollars[2]										
TOTAL	All	48,652	51,919	55,140	58,650	62,842	69,433	75,925	77,160	78,477	80,680	80,436
High-technology manufacturing industries	28,36,372,376,38	28,520	30,376	33,563	35,908	38,069	41,924	45,260	43,908	46,975	48,084	47,282
Other manufacturing industries	Other mfg SICs	18,172	19,426	19,549	20,270	21,561	22,956	24,614	26,710	24,822	25,910	26,604
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	1,960	2,117	2,029	2,472	3,213	4,553	6,051	6,542	6,680	6,687	6,550
Distribution by manufacturing industry												
Chemicals and allied products	28	5,139	5,408	5,987	6,604	6,918	7,358	7,697	7,769	8,205	8,878	9,134
Industrial chemicals	281-82,286	2,497	2,563	2,982	3,206	3,095	3,008	3,153	3,121	3,164	3,263	3,211
Drugs and medicines	283	1,931	2,073	D	D	D	D	D	3,214	D	3,912	D
Other chemicals	284-85,287-89	711	772	D	D	D	D	D	1,435	D	1,704	D
Petroleum refining and extraction	13,29	1,606	1,811	D	D	D	D	D	D	1,615	1,602	1,636
Rubber products	30	734	765	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	32	453	474	D	D	D	D	D	835	847	D	D
Primary metals	33	807	849	934	987	1,045	D	D	D	622	546	608
Fabricated metal products	34	579	642	664	625	675	782	747	786	667	683	624
Machinery	35	6,141	6,884	7,256	8,078	8,692	9,750	11,010	D	D	D	D
Office, computing, and accounting machines	357	4,091	4,622	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	351-56,358-59	2,050	2,262	D	D	D	D	D	2,105	2,068	2,241	2,208
Electrical equipment	36	9,958	10,703	10,993	10,923	12,210	12,789	13,008	13,161	13,496	13,387	13,275
Radio and TV receiving equipment	365	312	649	D	D	D	D	D	117	118	115	67
Communication equipment	366	4,626	4,694	5,064	5,839	7,027	8,062	8,470	8,495	8,672	8,486	8,319
Electronic components	367	1,488	1,805	1,674	1,740	2,088	2,628	3,051	D	3,650	3,797	3,867
Other electrical equipment	361-64,369	3,532	3,556	D	D	D	D	D	D	1,055	989	1,022
Transportation equipment	37	16,175	16,700	D	D	D	D	D	27,478	29,163	29,950	29,185
Motor vehicles and motor vehicles equipment	371	5,739	5,780	5,115	4,797	5,120	5,622	6,295	D	D	D	D
Other transportation equipment	373-75,379	202	189	D	D	D	D	D	D	D	D	D
Aircraft and missiles	372,376	10,234	10,730	12,737	14,451	14,833	17,505	20,037	18,494	20,828	21,347	20,310
Professional and scientific instruments	38	3,188	3,534	3,846	3,930	4,107	4,272	4,518	4,483	4,447	4,472	4,563
Scientific and mechanical measuring instruments	381-82	1,209	1,577	D	D	D	D	D	D	D	1,429	1,479
Optical, surgical, photographic, and other instruments	383-87	1,979	1,956	D	D	D	D	D	D	D	3,043	3,084
Distribution by size of company[1]												
Less than 500		2,245	2,409	2,453	2,934	4,258	4,086	5,287	6,212	6,100	D	5,895
500 - 999												
1,000 - 4,999		3,160	3,151	3,350	3,864	4,023	5,124	5,624	6,565	6,184	6,262	6,209
5,000 - 9,999		2,152	2,366	3,180	2,751	2,694	3,018	3,625	3,735	3,833	4,316	4,335

(continued)

Appendix table 6-16.
Total expenditures for industrial R&D (financed by company, Federal, and other funds), by industry and size of company: 1979-89
(page 3 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of constant 1982 dollars[2]										
10,000 - 24,999		6,607	7,019	7,197	7,943	9,146	10,537	10,013	9,219	10,255	9,456	8,259
25,000 or more		34,488	36,973	38,960	41,156	42,723	45,333	49,891	50,071	50,635	53,308	54,378

D = withheld to avoid disclosing operations of individual companies

S = withheld because of imputation of more than 50 percent

[1] Distribution is based on number of employees.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Research and Development in Industry: 1989*, NSF 91-302 (Washington, DC: NSF, 1991).

See figure 6-13.

Science & Engineering Indicators – 1991

Appendix table 6-17.

Federal funds for industrial R&D performance, by industry and size of company: 1979-89

(page 1 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of current dollars										
TOTAL	All	12,518	14,029	16,382	18,545	20,680	23,396	27,196	27,891	30,752	32,306	31,366
High-technology manufacturing industries	28,36,372,276,38	9,988	11,317	13,506	15,436	16,762	19,417	22,364	20,727	24,380	25,566	25,069
Other manufacturing industries	Other mfg SICs	1,849	1,933	2,018	2,109	2,665	2,326	2,519	4,458	3,672	3,987	3,581
Nonmanufacturing industries	10-11,14-17,40 42,44-51,53-54, 56,60,62-63,72- 73,78,806-07,87	681	779	858	1,000	1,253	1,653	2,313	2,706	2,700	2,753	2,716
Distribution by manufacturing industry												
Chemicals and allied products	28	346	372	421	407	393	191	230	179	190	199	88
Industrial chemicals	281-82,286	345	341	409	396	386	183	217	178	185	196	84
Drugs and medicines	283	D	D	D	D	D	D	D	1	D	3	D
Other chemicals	284-85,287-89	D	D	D	D	D	D	D	0	D	0	D
Petroleum refining and extraction	13,29	153	151	D	D	D	D	D	D	14	21	S
Rubber products	30	D	D	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	32	D	D	D	D	D	D	D	9	10	D	D
Primary metals	33	95	135	176	276	384	D	D	D	19	21	34
Fabricated metal products	34	41	49	80	60	67	69	49	95	150	142	135
Machinery	35	335	647	694	851	1,116	1,192	1,495	D	D	D	D
Office, computing, & accounting machines	357	256	D	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	351-56,358-59	79	D	D	D	D	D	D	75	44	98	106
Electrical equipment	36	3,309	3,744	3,920	4,241	4,523	4,741	5,161	5,213	5,399	5,370	5,222
Radio and TV receiving equipment	365	53	210	D	D	D	D	D	0	0	0	0
Communication equipment	366	1,586	1,657	1,783	2,284	2,798	3,538	4,223	4,552	4,729	4,621	4,666
Electronic components	367	D	382	361	398	359	477	559	D	656	728	522
Other electrical equipment	361-64,369	D	1,495	D	D	D	D	D	D	14	21	34
Transportation equipment	37	D	D	D	D	D	D	D	17,708	20,784	22,176	21,763
Motor vehicles and motor vehicles equipment	371	729	655	587	476	564	673	820	D	D	D	D
Other transportation equipment	373-75,379	D	D	D	D	D	D	D	D	D	D	D
Aircraft and missiles	372,376	5,840	6,628	8,528	10,265	11,396	14,094	16,582	14,984	18,519	19,877	19,634
Professional and scientific instruments	38	493	573	637	523	450	391	391	351	272	120	125
Scientific & mechanical measuring instruments	381-82	203	350	D	D	D	D	D	D	D	S	S
Optical, surgical, photographic, and other instruments	383-87	290	223	D	D	D	D	D	D	D	96	115
Distribution by size of company[1]												
Less than 500		389	354	424	523	641	621	739	868	963	864	940
500 - 999		D	D	D	D	D	98	117	137	115	139	105
1,000 - 4,999		590	444	562	623	740	902	991	1,229	981	1,157	1,113
5,000 - 9,999		228	432	619	527	718	487	672	796	748	914	813
10,000 - 24,999		1,179	1,150	1,225	1,495	2,271	2,805	2,743	2,004	2,362	1,805	1,245
25,000 or more		10,132	11,648	13,551	15,377	16,311	18,483	21,933	23,213	25,583	27,428	27,150

(continued)

Appendix table 6-17.

Federal funds for industrial R&D performance, by industry and size of company: 1979-89

(page 2 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of constant 1982 dollars[2]										
TOTAL	All	15,932	16,366	17,435	18,545	19,911	21,717	24,512	24,504	26,188	26,627	24,833
High-technology manufacturing industries	28,36,372,276,38	12,712	13,202	14,374	15,436	16,139	18,024	20,157	18,210	20,761	21,071	19,847
Other manufacturing industries	Other mfg SICs	2,353	2,255	2,148	2,109	2,566	2,159	2,270	3,917	3,127	3,286	2,835
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	867	909	913	1,000	1,206	1,534	2,085	2,377	2,299	2,269	2,150
Distribution by manufacturing industry												
Chemicals and allied products	28	440	434	448	407	378	177	207	157	162	164	70
Industrial chemicals	281-82,286	439	398	435	396	372	170	196	156	158	162	67
Drugs and medicines	283	D	D	D	D	D	D	D	1	D	2	D
Other chemicals	284-85,287-89	D	D	D	D	D	D	D	D	D	D	D
Petroleum refining and extraction	13,29	195	176	D	D	D	D	D	D	12	17	D
Rubber products	30	D	D	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	32	D	D	D	D	D	D	D	8	9	D	D
Primary metals	33	121	157	187	276	370	D	D	D	16	17	27
Fabricated metal products	34	52	57	85	60	65	64	44	83	128	117	107
Machinery	35	426	755	739	851	1,075	1,106	1,347	D	D	D	D
Office, computing, and accounting machines	357	326	D	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	351-56,358-59	101	D	D	D	D	D	D	66	37	81	84
Electrical equipment	36	4,212	4,368	4,172	4,241	4,355	4,401	4,652	4,580	4,598	4,426	4,134
Radio and TV receiving equipment	365	67	245	D	D	D	D	D	D	D	D	D
Communication equipment	366	2,019	1,933	1,898	2,284	2,694	3,284	3,806	3,999	4,027	3,809	3,694
Electronic components	367	D	446	384	398	346	443	504	D	559	600	413
Other electrical equipment	361-64,369	D	1,744	D	D	D	D	D	D	12	17	27
Transportation equipment	37	D	D	D	D	D	D	D	15,558	17,699	18,277	17,230
Motor vehicles and motor vehicles equipment	371	928	764	625	476	543	625	739	D	D	D	D
Other transportation equipment	373-75,379	D	D	D	D	D	D	D	D	D	D	D
Aircraft and missiles	372,376	7,433	7,732	9,076	10,265	10,972	13,083	14,945	13,165	15,770	16,383	15,544
Professional and scientific instruments	38	627	668	678	523	433	363	352	308	232	99	99
Scientific and mechanical measuring instruments	381-82	258	408	D	D	D	D	D	D	D	D	D
Optical, surgical, photographic, and other instruments	383-87	369	260	D	D	D	D	D	D	D	79	91
Distribution by size of company[1]												
Less than 500		495	413	451	523	617	576	666	763	820	712	744
500 - 999		D	D	D	D	D	91	105	120	98	115	83
1,000 - 4,999		751	518	598	623	712	837	893	1,080	835	954	881
5,000 - 9,999		290	504	659	527	691	452	606	699	637	753	644

(continued)

Appendix table 6-17.

Federal funds for industrial R&D performance, by industry and size of company: 1979-89

(page 3 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of constant 1982 dollars[2]										
10,000 - 24,999		1,501	1,342	1,304	1,495	2,187	2,604	2,472	1,761	2,011	1,488	986
25,000 or more		12,896	13,588	14,422	15,377	15,705	17,157	19,768	20,394	21,786	22,606	21,495

D = withheld to avoid disclosing operations of individual companies

S = withheld because of imputation of more than 50 percent

[1] Distribution is based on number of employees.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Research and Development in Industry*: 1989, NSF 91-302 (Washington, DC : NSF, 1991).

See figure 6-14.

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Appendix table 6-18.

Company and other (except Federal) funds for industrial R&D performance, by industry and size of company: 1979-89

(page 1 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of current dollars										
TOTAL	All	25,708	30,476	35,428	40,105	44,588	51,404	57,043	59,932	61,403	65,583	70,233
High-technology manufacturing industries	28,36,372,376,38	8,728	10,457	12,827	14,275	15,984	18,012	19,542	20,585	21,338	22,201	23,204
Other manufacturing industries	Other mfg SICs	16,121	18,982	21,553	24,358	26,520	30,140	33,100	34,607	34,921	38,022	41,472
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	859	1,037	1,048	1,472	2,084	3,252	4,401	4,740	5,144	5,360	5,557
Distribution by manufacturing industry												
Chemicals and allied products	28	3,692	4,264	5,205	6,197	6,792	7,736	8,310	8,664	9,445	10,573	11,449
Industrial chemicals	281-82,286	1,617	1,856	2,393	2,810	2,828	3,057	3,281	3,374	3,531	3,763	3,972
Drugs and medicines	283	D	D	2,064	2,473	2,896	3,310	3,481	3,657	4,095	4,743	5,206
Other chemicals	284-85,287-89	D	653	747	914	1,068	1,369	1,548	1,633	1,819	2,067	2,271
Petroleum refining and extraction	13,29	1,109	1,401	1,780	2,003	2,074	2,245	2,194	1,971	1,883	1,923	2,050
Rubber products	30	D	D	598	617	638	671	659	655	596	635	679
Stone, clay, and glass products	32	D	D	411	472	586	705	825	941	985	826	861
Primary metals	33	539	594	702	711	701	683	730	786	711	642	734
Fabricated metal products	34	414	501	545	565	634	773	780	800	633	687	653
Machinery	35	4,490	5,254	6,124	7,227	7,911	9,312	10,721	10,701	10,577	11,992	13,216
Office, computing, and accounting machines	357	2,958	D	3,847	4,944	5,634	7,011	8,418	8,380	8,193	9,371	10,533
Other machinery, except electrical	351-56,358-59	1,532	D	2,277	2,283	2,277	2,301	2,303	2,321	2,384	2,621	2,683
Electrical equipment	36	4,515	5,431	6,409	6,682	8,158	9,037	9,271	9,767	10,449	10,872	11,546
Radio and TV receiving equipment	365	192	346	358	364	324	362	350	133	139	139	85
Communication equipment	366	2,049	2,367	2,975	3,555	4,500	5,147	5,174	5,117	5,455	5,675	5,842
Electronic components	367	D	1,165	1,212	1,342	1,810	2,354	2,826	3,357	3,630	3,879	4,362
Other electrical equipment	361-64,369	D	1,553	1,864	1,421	1,524	1,174	921	1,160	1,225	1,179	1,257
Transportation equipment	37	D	6,958	7,739	8,621	8,991	10,406	12,092	13,567	13,462	14,162	15,100
Motor vehicles and motor vehicles equipment	371	3,780	4,300	4,219	4,321	4,754	5,384	6,164	7,171	7,167	7,769	8,726
Other transportation equipment	373-75,379	D	D	80	114	227	258	279	330	356	370	354
Aircraft and missiles	372,376	2,201	2,570	3,440	4,186	4,010	4,764	5,649	6,066	5,939	6,023	6,020
Professional and scientific instruments	38	2,012	2,456	2,978	3,407	3,816	4,211	4,622	4,752	4,950	5,306	5,638
Scientific and mechanical measuring instruments	381-82	747	1,001	1,235	1,363	1,605	1,671	1,596	1,521	1,598	1,710	1,858
Optical, surgical, photographic, and other instruments	383-87	1,265	1,454	1,743	2,044	2,211	2,540	3,026	3,231	3,352	3,596	3,780
Distribution by size of company[1]												
Less than 500		1,375	1,711	1,880	2,411	3,781	3,781	5,127	6,203	6,200	S	S
500 - 999		D	D	D	D	D	1,341	1,531	1,765	1,610	1,517	1,613
1,000 - 4,999		1,893	2,257	2,586	3,241	3,438	4,618	5,249	6,243	6,281	6,441	6,730
5,000 - 9,999		1,463	1,596	2,369	2,224	2,080	2,764	3,350	3,455	3,753	4,322	4,662
10,000 - 24,999		4,012	4,867	5,537	6,448	7,228	8,546	8,366	8,489	9,681	9,668	9,187
25,000 or more		16,965	20,045	23,056	25,781	28,061	30,354	33,421	33,778	33,878	37,249	41,535

(continued)

Appendix table 6-18.

Company and other (except Federal) funds for industrial R&D performance, by industry and size of company: 1979-89

(page 2 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Millions of constant 1982 dollars[2]										
TOTAL	All	32,720	35,553	37,705	40,105	42,931	47,716	51,413	52,655	52,289	54,053	55,604
High-technology manufacturing industries	28,36,372,376,38	11,109	12,199	13,652	14,275	15,390	16,720	17,613	18,086	18,171	18,298	18,371
Other manufacturing industries	Other mfg SICs	20,518	22,144	22,938	24,358	25,534	27,977	29,833	30,405	29,738	31,338	32,834
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	1,093	1,210	1,115	1,472	2,007	3,019	3,967	4,164	4,380	4,418	4,399
Distribution by manufacturing industry												
Chemicals and allied products	28	4,699	4,974	5,540	6,197	6,540	7,181	7,490	7,612	8,043	8,714	9,064
Industrial chemicals	281-82,286	2,058	2,165	2,547	2,810	2,723	2,838	2,957	2,964	3,007	3,101	3,145
Drugs and medicines	283	D	D	2,197	2,473	2,788	3,072	3,137	3,213	3,487	3,909	4,122
Other chemicals	284-85,287-89	D	762	795	914	1,028	1,271	1,395	1,435	1,549	1,704	1,798
Petroleum refining and extraction	13,29	1,411	1,634	1,894	2,003	1,997	2,084	1,977	1,732	1,604	1,585	1,623
Rubber products	30	D	D	636	617	614	623	594	575	508	523	538
Stone, clay, and glass products	32	D	D	437	472	564	654	744	827	839	681	682
Primary metals	33	686	693	747	711	675	634	658	691	605	529	581
Fabricated metal products	34	527	584	580	565	610	718	703	703	539	566	517
Machinery	35	5,715	6,129	6,518	7,227	7,617	8,644	9,663	9,402	9,007	9,884	10,463
Office, computing, and accounting machines	357	3,765	D	4,094	4,944	5,425	6,508	7,587	7,363	6,977	7,724	8,339
Other machinery, except electrical	351-56,358-59	1,950	D	2,423	2,283	2,192	2,136	2,076	2,039	2,030	2,160	2,124
Electrical equipment	36	5,746	6,336	6,821	6,682	7,855	8,389	8,356	8,581	8,898	8,961	9,141
Radio and TV receiving equipment	365	244	404	381	364	312	336	315	117	118	115	67
Communication equipment	366	2,608	2,761	3,166	3,555	4,333	4,778	4,663	4,496	4,645	4,677	4,625
Electronic components	367	D	1,359	1,290	1,342	1,743	2,185	2,547	2,949	3,091	3,197	3,453
Other electrical equipment	361-64,369	D	1,812	1,984	1,421	1,467	1,090	830	1,019	1,043	972	995
Transportation equipment	37	D	8,117	8,236	8,621	8,657	9,659	10,899	11,920	11,464	11,672	11,955
Motor vehicles and motor vehicles equipment	371	4,811	5,016	4,490	4,321	4,577	4,998	5,556	6,300	6,103	6,403	6,908
Other transportation equipment	373-75,379	D	D	85	114	219	239	251	290	303	305	280
Aircraft and missiles	372,376	2,801	2,998	3,661	4,186	3,861	4,422	5,091	5,329	5,057	4,964	4,766
Professional and scientific instruments	38	2,561	2,865	3,169	3,407	3,674	3,909	4,166	4,175	4,215	4,373	4,464
Scientific and mechanical measuring instruments	381-82	951	1,168	1,314	1,363	1,545	1,551	1,438	1,336	1,361	1,409	1,471
Optical, surgical, photographic, and other instruments	383-87	1,610	1,696	1,855	2,044	2,129	2,358	2,727	2,839	2,854	2,964	2,993
Distribution by size of company[1]												
Less than 500		1,750	1,996	2,001	2,411	3,640	3,510	4,621	5,450	5,280	S	S
500 - 999		D	D	D	D	D	1,245	1,380	1,551	1,371	1,250	1,277
1,000 - 4,999		2,409	2,633	2,752	3,241	3,310	4,287	4,731	5,485	5,349	5,309	5,328
5,000 - 9,999		1,862	1,862	2,521	2,224	2,003	2,566	3,019	3,035	3,196	3,562	3,691

(continued)

Appendix table 6-18.

Company and other (except Federal) funds for industrial R&D performance, by industry and size of company: 1979-89

(page 3 of 3)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
10,000 - 24,999		5,106	5,678	5,893	6,448	6,959	7,933	7,540	7,458	8,244	7,968	7,273
25,000 or more		21,592	23,384	24,538	25,781	27,018	28,176	30,123	29,677	28,850	30,701	32,883

D = withheld to avoid disclosing operations of individual companies

S = withheld because of imputation of more than 50 percent

NOTE: Company funds include all funds for industrial R&D work performed within company facilities from all sources except the Federal Government. The sources of funds may comprise those from outside organizations such as research institutions, universities and colleges, other nonprofit organizations, other companies, and state governments, as well as companies' own. Company-financed R&D not performed within the company is excluded.

[1] Distribution is based on number of employees.

[2] See appendix table 4-1 for GNP implicit price deflators used to convert current dollars to constant 1982 dollars.

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Research and Development in Industry: 1989*, NSF 91-302(Washington, DC : NSF, 1991).

See figure 6-14.

Science & Engineering Indicators – 1991

Appendix table 6-19.

Share of R&D funding provided by the Federal Government in selected industries: 1979-89

(page 1 of 2)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Percent										
TOTAL	All	32.7	31.5	31.6	31.6	31.7	31.3	32.3	31.8	33.4	33.0	30.9
High-technology manufacturing industries	28,36,372,276,38	44.6	43.5	42.8	43.0	42.4	43.0	44.5	41.5	44.2	43.8	42.0
Other manufacturing industries	Other mfg SICs	12.9	11.6	11.0	10.4	11.9	9.4	9.2	14.7	12.6	12.7	10.7
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	44.2	42.9	45.0	40.5	37.5	33.7	34.5	36.3	34.4	33.9	32.8
Distribution by manufacturing industry												
Chemicals and allied products	28	8.6	8.0	7.5	6.2	5.5	2.4	2.7	2.0	2.0	1.8	0.8
Industrial chemicals	281-82,286	17.6	15.5	14.6	12.4	12.0	5.6	6.2	5.0	5.0	5.0	2.1
Drugs and medicines	283	D	D	D	D	D	D	D	0.0	D	0.1	D
Other chemicals	284-85,287-89	D	D	D	D	D	D	D	D	D	D	D
Petroleum refining and extraction	13,29	12.1	9.7	D	D	D	D	D	D	0.7	1.1	D
Rubber products	30	D	D	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	32	D	D	D	D	D	D	D	0.9	1.0	D	D
Primary metals	33	15.0	18.5	20.0	28.0	35.4	D	D	D	2.6	3.2	4.4
Fabricated metal products	34	9.0	8.9	12.8	9.6	9.6	8.2	5.9	10.6	19.2	17.1	17.1
Machinery	35	6.9	11.0	10.2	10.5	12.4	11.3	12.2	D	D	D	D
Office, computing, and accounting machines	357	8.0	D	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	351-56,358-59	4.9	D	D	D	D	D	D	3.1	1.8	3.6	3.8
Electrical equipment	36	42.3	40.8	38.0	38.8	35.7	34.4	35.8	34.8	34.1	33.1	31.1
Radio and TV receiving equipment	365	21.6	37.8	D	D	D	D	D	D	D	D	D
Communication equipment	366	43.6	41.2	37.5	39.1	38.3	40.7	44.9	47.1	46.4	44.9	44.4
Electronic components	367	D	24.7	22.9	22.9	16.6	16.8	16.5	D	15.3	15.8	10.7
Other electrical equipment	361-64,369	D	49.0	D	D	D	D	D	D	1.1	1.8	2.6
Transportation equipment	37	D	D	D	D	D	D	D	56.6	60.7	61.0	59.0
Motor vehicles and motor vehicles equipment	371	16.2	13.2	12.2	9.9	10.6	11.1	11.7	D	D	D	D
Other transportation equipment	373-75,379	D	D	D	D	D	D	D	D	D	D	D
Aircraft and missiles	372,376	72.6	72.1	71.3	71.0	74.0	74.7	74.6	71.2	75.7	76.7	76.5
Professional and scientific instruments	38	19.7	18.9	17.6	13.3	10.5	8.5	7.8	6.9	5.2	2.2	2.2
Scientific & mechanical measuring instruments	381-82	21.4	25.9	D	D	D	D	D	D	D	D	D
Optical, surgical, photographic, and other instruments	383-87	18.6	13.3	D	D	D	D	D	D	D	2.6	3.0

(continued)

Appendix table 6-19.
Share of R&D funding provided by the Federal Government in selected industries: 1979-89
(page 2 of 2)

Industry and company size	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Percent										
Distribution by size of company[1]												
Less than 500		22.1	17.1	18.4	17.8	14.5	14.1	12.6	12.3	13.4	D	12.6
500 - 999		D	D	D	D	D	6.8	7.1	7.2	6.7	8.4	6.1
1,000 - 4,999		23.8	16.4	17.9	16.1	17.7	16.3	15.9	16.4	13.5	15.2	14.2
5,000 - 9,999		13.5	21.3	20.7	19.2	25.7	15.0	16.7	18.7	16.6	17.5	14.8
10,000 - 24,999		22.7	19.1	18.1	18.8	23.9	24.7	24.7	19.1	19.6	15.7	11.9
25,000 or more		37.4	36.8	37.0	37.4	36.8	37.8	39.6	40.7	43.0	42.4	39.5

D = withheld to avoid disclosing operations of individual companies

[1] Distribution is based on number of employees.

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Research and Development in Industry: 1989*, NSF 91-302 (Washington, DC : NSF, 1991).

See figure 6-15.

Appendix table 6-20.

Company-financed R&D performed outside the United States by U.S. domestic companies and their foreign subsidiaries: 1979-89

	SIC code	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		Percent										
ALL INDUSTRIES	All	9.7	9.4	8.7	7.2	6.8	6.6	6.0	7.2	7.8	8.8	8.5
Chemicals and allied products	28	11.9	12.4	12.1	9.9	9.7	9.2	9.2	11.0	11.6	12.4	10.1
Drugs and medicines	283	D	D	17.2	12.8	11.1	10.8	10.3	11.9	13.1	13.2	13.5
Stone, clay, and glass products	32	D	D	4.2	2.1	3.1	7.8	D	D	D	D	D
Primary metals	33	2.0	1.8	1.3	1.3	1.4	1.3	D	D	2.5	3.6	3.0
Fabricated metal products	34	D	D	5.2	4.2	3.5	2.6	2.6	3.1	5.9	D	D
Machinery	35	10.6	10.2	9.1	6.4	6.8	7.4	6.0	8.2	10.4	10.2	9.9
Electrical equipment	36	9.0	7.7	6.9	6.5	5.6	5.6	6.0	S	4.0	5.8	5.1
Communication equipment	366	D	D	D	D	D	D	D	D	3.3	5.6	4.5
Electronic components	367	D	2.4	3.2	2.8	0.0	3.8	4.0	4.3	5.3	6.7	5.3
Transportation equipment	37	D	12.8	10.3	8.9	8.9	8.0	7.8	D	D	11.3	12.2
Aircraft and missiles	372,376	D	D	D	D	D	D	D	2.9	3.8	5.2	9.2
Professional and scientific instruments	38	7.2	7.0	7.2	6.5	D	5.9	3.5	4.3	6.0	6.9	7.3
Nonmanufacturing	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	0.6	0.7	0.8	0.5	0.5	0.2	0.4	0.6	1.2	1.7	1.6

D = withheld to avoid disclosing operations of individual companies

S = withheld because of imputation of more than 50 percent

SOURCE: Science Resources Sciences Division, National Science Foundation, *Selected Data on Research and Development in Industry: 1989*, NSF 91-302 (Washington, DC: NSF, 1991).

See figure 6-16.

Science & Engineering Indicators – 1991

Appendix table 6-21.

U.S. patents granted, by nationality of inventor and year of grant: 1963-90

	Total	1963-76	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TOTAL	1,902,916	924,876	65,263	66,098	48,850	61,810	65,766	57,882	56,855	67,186	71,649	70,778	82,860	77,799	95,262	89,982
U.S. origin	1,227,516	674,289	41,480	41,251	30,076	37,351	39,221	33,891	32,867	38,354	39,549	38,078	43,462	40,416	50,036	47,195
U.S. corporations owned	882,489	486,886	29,561	29,418	21,143	25,963	27,621	24,081	24,037	27,997	28,943	27,305	31,267	29,267	35,717	33,283
U.S. Government owned	38,244	23,268	1,484	1,233	961	1,232	1,116	1,003	1,044	1,229	1,125	1,013	973	728	865	970
U.S. individuals owned	300,270	161,580	10,249	10,399	7,803	9,939	10,240	8,538	7,558	8,881	9,245	9,453	10,853	10,066	12,989	12,477
Foreign owned	6,513	2,555	186	201	169	217	244	269	228	247	236	307	369	355	465	465
Foreign origin	675,400	250,587	23,783	24,847	18,774	24,459	26,545	23,991	23,988	28,832	32,100	32,700	39,398	37,383	45,226	42,787
U.S. owned	53,798	25,013	1,968	1,962	1,364	1,694	1,839	1,715	1,658	2,029	2,268	2,166	2,442	2,146	2,848	2,686
Foreign owned	621,602	225,574	21,815	22,885	17,410	22,765	24,706	22,276	22,330	26,803	29,832	30,534	36,956	35,237	42,378	40,101
Foreign corporations	512,515	175,152	17,880	18,873	14,446	18,662	20,546	18,587	19,020	22,988	25,716	26,223	31,977	30,575	36,937	34,933
Foreign governments	7,667	2,553	215	249	186	253	249	369	336	438	482	477	551	453	443	413
Foreign individuals	101,420	47,869	3,720	3,763	2,778	3,850	3,911	3,320	2,974	3,377	3,634	3,834	4,428	4,209	4,998	4,755
Foreign origin	675,400	250,587	23,783	24,847	18,774	24,459	26,545	23,991	23,988	28,832	32,100	32,700	39,398	37,383	45,226	42,787
European Community	337,183	149,763	12,316	12,646	9,538	12,198	12,934	11,346	10,937	12,729	13,826	13,877	16,246	15,080	17,684	16,063
Japan	203,580	43,481	6,217	6,910	5,250	7,124	8,387	8,149	8,792	11,109	12,743	13,198	16,539	16,137	20,100	19,444
West Germany	152,706	63,310	5,537	5,850	4,527	5,745	6,250	5,408	5,423	6,254	6,665	6,795	7,815	7,300	8,286	7,541
United Kingdom	73,534	38,901	2,654	2,722	1,910	2,406	2,475	2,134	1,931	2,271	2,495	2,408	2,777	2,581	3,091	2,778
France	57,500	25,094	2,108	2,119	1,604	2,088	2,181	1,975	1,895	2,162	2,398	2,365	2,868	2,655	3,134	2,854
Switzerland	32,935	14,679	1,219	1,226	862	1,081	1,135	990	1,000	1,206	1,340	1,311	1,593	1,488	1,957	1,848
Canada	32,628	15,388	1,346	1,330	1,025	1,265	1,239	1,147	1,017	1,174	1,233	1,208	1,373	1,244	1,358	1,281
Sweden	20,835	8,179	756	725	596	805	883	752	625	794	919	995	1,183	1,075	1,291	1,257
Italy	20,422	9,500	862	826	573	822	766	685	623	701	857	883	948	776	834	766
The Netherlands	18,283	7,902	708	659	525	654	641	618	626	726	766	721	921	805	1,060	951
Belgium	6,869	3,242	255	264	185	244	263	224	205	240	240	242	294	302	357	312
USSR	6,580	3,128	394	412	354	460	373	209	222	214	147	116	121	96	160	174
Hungary	1,909	505	80	66	63	87	98	112	106	111	108	131	127	94	129	92
East Germany	690	53	26	24	19	35	52	59	54	68	53	53	64	46	50	34
Taiwan	3,072	52	52	29	38	65	80	88	65	98	174	208	343	457	592	731
South Korea	807	51	5	12	4	8	15	14	26	29	38	45	84	95	157	224
Hong Kong	527	139	9	21	13	27	33	18	14	24	25	30	34	41	47	52

SOURCE: Patent and Trademark Office, *Patenting Trends in the United States, 1963-1989* (Washington, DC: August 1990).

See figures 6-17, 6-18, and 6-19, and figure O-21 in Overview.

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Appendix table 6-22.

U.S. patents granted, by nationality of inventor and year of application: 1963-90

	Total	1963-75	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987 (est.)	1988 (est.)	1989 (est.)	1990 (est.)
TOTAL	1,938,213	970,998	65,770	65,938	65,567	65,658	66,410	63,755	64,787	61,164	66,254	69,796	71,859	75,825	80,009	84,424	89,083
U.S. origin	1,235,891	702,113	41,615	40,811	39,618	38,951	38,887	36,720	36,434	34,252	35,778	36,719	37,017	37,987	38,983	40,005	41,054
U.S. corporations owned . .	889,561	507,214	29,130	28,504	27,721	27,320	27,624	26,740	27,018	25,336	26,155	26,806	26,754	27,244	27,743	28,251	28,769
U.S. Government owned . .	37,849	24,520	1,347	1,181	1,203	1,089	1,140	1,173	1,203	986	913	833	676	596	526	463	409
U.S. individuals owned . . .	302,391	167,706	10,943	10,901	10,464	10,281	9,845	8,553	7,962	7,680	8,418	8,780	9,273	9,874	10,515	11,196	11,922
Foreign owned	6,622	2,673	195	225	230	261	278	254	251	250	292	300	314	339	366	394	426
Foreign origin	702,323	268,885	24,155	25,127	25,949	26,707	27,523	27,035	28,353	26,912	30,476	33,077	34,842	37,837	41,026	44,419	48,029
U.S. owned	54,409	26,461	1,830	1,862	1,847	1,861	1,986	1,878	2,013	1,953	2,067	2,050	2,082	2,127	2,173	2,220	2,267
Foreign owned	649,291	242,424	22,325	23,265	24,102	24,846	25,537	25,157	26,340	24,959	28,409	31,027	32,760	35,869	39,272	42,999	47,080
Foreign corporations . .	536,895	189,140	18,232	19,135	19,801	20,468	21,447	21,424	22,845	21,564	24,448	27,023	28,444	31,194	34,211	37,519	41,147
Foreign governments . .	8,070	2,728	238	265	283	270	411	384	428	407	456	425	431	439	448	456	465
Foreign individuals. . . .	104,374	50,556	3,855	3,865	4,018	4,108	3,679	3,349	3,067	2,988	3,505	3,579	3,885	4,240	4,628	5,051	5,513
Foreign origin	702,323	268,885	24,155	25,127	25,949	26,707	27,523	27,035	28,353	26,912	30,476	33,077	34,842	37,837	41,026	44,419	48,029
European Community	349,096	159,469	12,242	12,685	13,041	12,922	12,933	12,195	12,295	11,551	12,982	13,611	14,201	15,213	16,297	17,459	18,703
Japan	216,252	48,271	6,576	7,078	7,475	8,414	9,557	10,009	11,300	10,734	12,316	14,099	14,856	16,556	18,450	20,561	22,913
West Germany.	159,135	67,655	5,572	5,969	6,190	6,135	6,176	6,050	5,983	5,473	6,208	6,694	6,889	7,438	8,031	8,671	9,363
United Kingdom	74,767	41,056	2,620	2,636	2,524	2,497	2,371	2,197	2,203	2,143	2,336	2,354	2,347	2,419	2,494	2,570	2,650
France.	59,450	26,726	2,128	2,099	2,272	2,223	2,301	2,072	2,125	2,068	2,224	2,317	2,481	2,636	2,801	2,976	3,163
Switzerland	33,678	16,460	1,321	1,319	1,358	1,236	1,261	1,131	1,121	1,040	1,131	1,130	1,201	1,260	1,322	1,387	1,455
Canada	33,285	15,387	1,206	1,228	1,172	1,210	1,124	1,157	1,107	1,088	1,284	1,281	1,351	1,452	1,561	1,678	1,803
Sweden.	20,858	10,133	856	843	805	824	748	689	671	739	804	778	741	742	742	743	744
Italy.	22,196	8,736	747	766	808	918	856	715	798	722	939	932	1,069	1,218	1,389	1,583	1,804
The Netherlands.	18,635	8,444	655	704	709	649	717	670	702	642	715	747	755	797	841	888	937
Belgium.	7,268	3,479	241	230	267	239	246	231	213	214	238	253	298	333	372	415	463
USSR	6,521	3,427	427	449	466	367	246	251	182	115	95	94	105	102	99	96	93
Hungary	1,969	576	77	84	74	103	123	122	112	105	116	104	97	94	92	90	87
East Germany	784	77	19	33	30	60	63	67	62	38	56	48	50	55	60	66	72
Taiwan	3,750	81	44	36	68	85	99	65	118	116	158	250	349	504	727	1,050	1,516
South Korea.	801	56	8	8	8	17	17	22	36	37	33	69	80	103	134	173	224
Hong Kong	574	147	13	28	27	21	28	14	24	22	22	24	38	46	55	66	79

SOURCE: Patent and Trademark Office, *Patenting Trends in the United States, 1963-1989* (Washington, DC: August 1990).

See figures 6-17 and 6-19.

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Appendix table 6-23.

Patent classes most and least emphasized by U.S. corporations patenting in the United States: 1980 and 1989

	Class	Activity index	
Patent class	number	1980	1989
Most emphasized classes			
Mineral oils: processes and products	208	1.775	1.919
Chemistry, hydrocarbons	585	1.748	1.896
Wells	166	1.692	1.857
Chemistry, lignins or reaction products thereof	530	1.181	1.604
Catalyst, solid sorbent, or support therefor, product	502	1.520	1.539
Communications, electrical: Acoustic wave system and devices	367	0.911	1.485
Communication, directive radio wave systems & devices	342	0.991	1.482
Chemistry: Analytical and immunological testing	436	1.432	1.469
Part of the class 520 series—synth. resins or natural rubber	525	1.364	1.468
Electrical connectors	439	1.623	1.455
Chemistry: Molecular biology and microbiology	435	1.090	1.438
Induced nuclear reaction, systems and elements	376	0.910	1.374
Chemistry, electrical current producing apparatus, prod. & proc.	429	1.300	1.372
Semiconductor device manufacturing: Process	437	1.554	1.342
Electricity, conductors and insulators	174	1.295	1.335
Error detection/correction and fault detection/recovery	371	1.318	1.326
Drug, bio-affecting and body treating compositions	424	0.920	1.324
Part of the class 520 series—synth. resins or natural rubber..	521	1.217	1.322
Amplifiers	330	1.231	1.321
Part of the class 520 series—synth. resins or natural rubber..	524	1.291	1.293
Least emphasized classes			
Fishing, trapping and vermin destroying	43	0.328	0.360
Dynamic information storage or retrieval	369	0.760	0.368
Baths, closets, sinks and spittoons	4	0.617	0.467
Fluid: Pressure brake and analogous systems	303	0.619	0.481
Photography	354	0.526	0.484
Photocopying	355	0.932	0.487
Ships	114	0.514	0.497
Land vehicles	280	0.555	0.508
Amusement devices, games	273	0.436	0.509
Motor vehicles	180	0.794	0.515
Internal-combustion engines	123	0.491	0.555
Amusement and exercising devices	272	0.312	0.568
Package and article carriers	224	0.333	0.583
Optics, eye examining, vision testing and correcting	351	0.952	0.606
Beds	5	0.631	0.611
Animal husbandry	119	0.582	0.614
Pictorial communication; television	358	0.962	0.619
Endless belt power transmission systems and components	474	0.766	0.625
Typewriting machines	400	1.145	0.626
Bleaching and dyeing; Fluid treatment and chem. modification	8	0.612	0.629

NOTES: The activity index is the percentage of the patents in a class that are granted to U.S. inventors, divided by the percentage of all patents that have U.S. inventors in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

Appendix table 6-24.
Patent classes most and least emphasized by Japanese inventors patenting in the United States: 1980 and 1989

Patent class	Class number	Activity index	
		1980	1989
Most emphasized classes			
Photocopying	355	2.776	3.581
Photography	354	4.606	3.324
Dynamic information storage or retrieval	369	3.372	3.320
Dynamic magnetic information storage or retrieval	360	3.235	2.966
Radiation imagery chemistry—process, composition or products	430	3.332	2.760
Pictoral communication; television	358	2.587	2.744
Typewriting machines	400	1.388	2.622
Static information storage and retrieval	365	1.236	2.458
Recorders	346	2.170	2.406
Motor vehicles	180	1.091	2.246
Image analysis	382	2.082	2.059
Internal-combustion engines	123	3.106	1.941
Active solid state devices, e.g., transistors, solid st. diodes	357	2.061	1.939
Registers	235	1.122	1.749
Coherent light generators	372	0.349	1.737
Compositions: Ceramic	501	2.297	1.698
Metal treatment	148	2.568	1.690
Electricity, motive power systems	318	1.746	1.675
Clutches and power-stop control	192	1.614	1.671
Endless belt power transmission systems and components	474	2.255	1.645
Least emphasized classes			
Wells	166	0.000	0.000
Boring or penetrating the earth	175	0.064	0.000
Apparel	2	0.062	0.035
Aeronautics	244	0.096	0.035
Amusement and exercising devices	272	0.193	0.087
Ammunition and explosives	102	0.063	0.088
Animal husbandry	119	0.228	0.093
Locks	70	0.146	0.112
Ships	114	0.382	0.118
Baths, closets, sinks and spittoons	4	0.053	0.137
Card, picture and sign exhibiting	40	0.239	0.141
Package and article carriers	224	0.000	0.144
Tools	81	0.238	0.147
Beds	5	0.115	0.165
Static structures, e.g., buildings	52	0.091	0.169
Bottles and jars	215	0.378	0.169
Fishing, trapping and vermin destroying	43	0.347	0.191
Prothesis (i.e., artificial body members), parts or aids	623	0.446	0.206
Mineral oils: Processes and products	208	0.505	0.249
Chemistry: Analytical and immunological testing	436	0.587	0.250

NOTES: The activity index is the percentage of the patents in a class that are granted to Japanese inventors, divided by the percentage of all patents that have Japanese inventors in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

Appendix table 6-25.
Patent classes most and least emphasized by West German inventors patenting in the United States: 1980 and 1989

Patent class	Class number	Activity index	
		1980	1989
Most emphasized classes			
Fluid-pressure brake and analogous systems	303	2.329	4.655
Bleaching and dyeing; Fluid treatment and chem. modification	8	3.510	2.919
Ammunition and explosives	102	1.248	2.895
Part of the class 532-570 series—organic compounds	544	1.455	2.802
Printing	101	2.068	2.660
Part of the class 532-570 series—organic compounds	560	1.485	2.582
Bearing or guides	384	2.648	2.507
X-ray or gamma ray systems or devices	378	2.783	2.391
Solid material comminution or disintegration	241	1.460	2.248
Part of the class 532-570 series—organic compounds	568	1.877	2.222
Spring devices	267	1.254	2.183
Chemistry, fertilizers	71	1.156	2.176
Part of the class 520 series—synth. resins or natural rubber	526	1.269	2.144
Glass manufacturing	65	0.793	2.105
Part of the class 520 series—synth. resins or natural rubber	528	2.043	2.030
Part of the class 532-570 series—organic compounds	548	1.202	2.019
Metal deforming	72	1.391	1.908
Part of the class 532-570 series—organic compounds	546	1.919	1.879
Part of the class 520 series—synth. resins or natural rubber	521	2.263	1.836
Induced nuclear reaction, systems and elements	376	1.902	1.817
Least emphasized classes			
Amusement devices, games	273	0.150	0.018
Fishing, trapping and vermin destroying	43	0.000	0.032
Beds	5	0.076	0.054
Wells	166	0.096	0.089
Amusement and exercising devices	272	0.170	0.115
Photocopying	355	1.126	0.116
Amusement devices, toys	446	0.208	0.120
Animal husbandry	119	0.181	0.123
Package and article carriers	224	0.575	0.127
Apparel	2	0.328	0.231
Image analysis	382	0.499	0.239
Communications, directive radio wave systems and devices	342	0.546	0.263
Ships	114	0.360	0.266
Recorders	346	0.911	0.284
Mineral oils: Processes and products	208	0.374	0.288
Surgery	604	0.348	0.312
Card, picture and sign exhibiting	40	0.189	0.319
Dynamic magnetic information storage or retrieval	360	0.660	0.319
Coded data generation or conversion	341	0.793	0.324
Stoves and furnaces	126	0.343	0.327

NOTES: The activity index is the percentage of the patents in a class that are granted to West German inventors, divided by the percentage of all patents that have West German inventors in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

Appendix table 6-26.
Patent classes most and least emphasized by French inventors patenting in the United States: 1980 and 1989

Patent class	Class number	Activity index 1980	Activity index 1989
Most emphasized classes			
Bleaching and dyeing: Fluid treatment and chem. modification	8	2.195	4.794
Induced nuclear reaction, systems and elements	376	1.621	3.239
Spring devices	267	0.935	3.122
Boring or penetrating the earth	175	1.520	3.107
Communication, electrical: Acoustic wave systems and devices	367	1.389	2.914
Glass manufacturing	65	1.520	2.479
Part of the class 532-570 series—organic compounds	568	1.264	2.469
Land vehicles	280	1.159	2.413
Brakes	188	2.379	2.304
Part of the class 520 series—synth. resins or natural rubber	526	1.548	2.284
Part of the class 532-570 series—organic compounds	562	1.242	2.281
Multiplex communication	370	1.949	2.273
Pipe joints or couplings	285	1.243	2.200
Electricity, circuit makers and breakers	200	0.646	2.049
Metal founding	164	2.473	2.026
Package making	53	1.242	2.012
Expanded, threaded, headed, and driven fasteners-locked	411	1.338	1.958
Clutches and power-stop control	192	2.279	1.943
Registers	235	4.118	1.943
Part of the class 532-570 series—organic compounds	560	0.591	1.901
Drug, bio-affecting and body treating compositions	424	1.753	1.896
Least emphasized classes			
Photography	354	0.000	0.000
Package and article carriers	224	0.000	0.000
Fishing, trapping and vermin destroying	43	0.390	0.000
Baths, closets, sinks and spittoons	4	0.207	0.000
Amusement and exercising devices	272	0.000	0.112
Photocopying	355	0.240	0.113
Land vehicles, bodies and tops	296	0.644	0.117
Dynamic magnetic information storage or retrieval	360	0.918	0.123
Radiation imagery chemistry—process, composition or product	430	0.317	0.135
Coherent light generators	372	0.548	0.154
Stoves and furnaces	126	0.472	0.160
Tools	81	0.623	0.164
Solid material comminution or disintegration	241	1.089	0.170
Amusement devices, toys	446	0.000	0.177
Animal husbandry	119	0.180	0.181
Amusement devices, games	273	0.224	0.210
Cutlery	30	0.183	0.259
Apparel	2	0.000	0.272
Electricity, conductors and insulators	174	0.784	0.284
Printing	101	1.410	0.285
Dentistry	433	1.013	0.296

NOTES: The activity index is the percentage of the patents in a class that are granted to French inventors, divided by the percentage of all patents that have French inventors in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

Appendix table 6-27.
Patent classes most and least emphasized by British inventors patenting in the United States: 1980 and 1989

Patent class	Class number	Activity index 1980	Activity index 1989
Most emphasized classes			
Drug, bio-affecting and body treating compositions	514	2.756	2.890
Aeronautics	244	0.775	2.749
Communications, directive radio wave systems and devices	342	1.342	2.301
Sheet feeding or delivering	271	0.829	2.279
Brakes	188	2.288	2.254
Compositions, coating or plastic	106	2.148	2.139
Closure fasteners	292	0.401	2.073
Dispensing	222	0.852	1.995
Coded data generation or conversion	341	0.835	1.917
Telecommunications	455	0.881	1.912
Classifying, separating and assorting solids	209	1.490	1.905
Spring devices	267	0.000	1.873
Multiplex communications	370	1.148	1.820
Part of the class 532-570 series—organic compounds	546	0.404	1.820
Power plants	60	2.192	1.801
Optics, systems and elements	350	1.660	1.792
Glass manufacturing	65	2.506	1.788
Communications, radio wave antennas	343	0.409	1.762
Chemistry, fertilizers	71	1.539	1.752
Drug, bio-affecting and body treating compositions	424	2.674	1.725
Least emphasized classes			
Amusement devices, toys	446	0.256	0.000
Dentistry	433	0.278	0.000
Cleaning and liquid contact with solids	134	0.481	0.000
Baths, closets, sinks and spittoons	4	0.513	0.000
Fishing, trapping and vermin destroying	43	0.000	0.086
Electric power conversion systems	363	1.583	0.128
Error detection/correction and fault detection/recovery	371	1.398	0.136
Amusement devices, games	273	0.308	0.146
Beds	5	0.560	0.149
Tools	81	0.257	0.152
Dynamic information storage or retrieval	369	1.262	0.159
Photography	354	0.258	0.168
Endless belt power transmission systems and components	474	0.000	0.174
Amusement and exercising devices	272	0.000	0.209
Winding and reeling	242	0.250	0.238
Part of the class 520 series—synth. resins or natural rubber	525	0.526	0.260
Dynamic magnetic information storage or retrieval	360	0.216	0.265
Static information storage and retrieval	365	1.002	0.286
Chairs and seats	297	1.032	0.303
Supports	248	0.545	0.315

NOTES: The activity index is the percentage of the patents in a class that are granted to British inventors, divided by the percentage of all patents that have British inventors in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

Appendix table 6-28.
Patent classes most emphasized by inventors from Taiwan patenting in the United States: 1980 and 1989

Patent class	Class number	Activity index 1980	Activity index 1989
Locks	70	0.000	14.442
Telephonic communications	379	0.000	14.118
Cutlery	30	0.000	12.870
Image analysis	382	0.000	8.759
Valves and valve actuation	251	0.000	8.016
Semiconductor device manufacturing process	437	0.000	6.793
Illumination	362	0.000	6.320
Part of the class 532-570 series—organic compounds	568	0.000	6.142
Chairs and seats	297	0.000	5.421
Closure fasteners	292	0.000	4.637
Part of the class 532-570 series—organic compounds	546	69.304	4.441
Baths, closets, sinks and spittoons	4	0.000	4.420
Amusement devices, toys	446	131.530	4.400
Internal-combustion engines	123	0.000	4.359
Optics, eye examining, vision testing and correcting	351	0.000	4.359
Miscellaneous hardware	16	0.000	4.319
Tools	81	0.000	4.077
Receptacles	220	0.000	3.941
Bearing or guides	384	0.000	3.909
Cutting	83	0.000	3.893
Electricity, conductors and insulators	174	0.000	3.530
Electric lamp and discharge devices, systems	315	0.000	3.465
Ships	114	0.000	3.251
Registers	235	0.000	3.022
Abrading	51	0.000	2.841
Amusement and exercising devices	272	0.000	2.799
Metal treatment	148	0.000	2.726
Pulse or digital communications	375	0.000	2.695
Package making	53	0.000	2.635
Amusement devices, games	273	0.000	2.613
Brushing, scrubbing and general cleaning	15	0.000	2.606
Special receptacle or package	206	0.000	2.553
Fishing, trapping and vermin destroying	43	0.000	2.313
Catalyst, solid sorbent, or support therefor, prod. or proc	502	0.000	2.296
Photography	354	0.000	2.258
Electric heating	219	0.000	2.157
Dynamic information storage or retrieval	369	0.000	2.135
Dynamic magnetic information storage or retrieval	360	0.000	2.032
Coherent light generators	372	0.000	1.911
Metal working	29	0.000	1.698
Measuring and testing	73	0.000	1.490
Land vehicles	280	0.000	1.334
Liquid purification or separation	210	0.000	0.871
Drug, bio-affecting and body treating compositions	424	0.000	0.858
Radiation imagery chemistry—process, composition or product	430	0.000	0.839
Drug, bio-affecting and body treating compositions	514	0.000	0.384
Electrical computers and data processing systems	364	0.000	0.334

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from Taiwan, divided by the percentage of all patents that have inventors from Taiwan in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

Appendix table 6-29.
Patent classes most emphasized by South Korean inventors patenting in the United States: 1980 and 1989

Patent class	Class number	Activity index 1980	Activity index 1989
Static information storage and retrieval	365	0.000	9.056
Closure fasteners	292	0.000	8.754
Dynamic magnetic information storage or retrieval	360	0.000	8.632
Miscellaneous hardware	16	0.000	8.154
Pictorial communication; television	358	0.000	7.855
Electric lamp and discharge devices, systems	315	0.000	6.541
Electrical transmission or interconnection systems	307	0.000	5.890
Receptacles	220	0.000	5.581
Chairs and seats	297	0.000	5.117
Electric heating	219	0.000	5.091
Electric lamp and discharge devices	313	0.000	4.699
Part of the class 520 series—synth. resins or natural rubber	521	0.000	4.232
Amusement devices, toys	446	0.000	4.153
Winding and reeling	242	0.000	4.013
Sheet feeding or delivering	271	0.000	3.849
Electrical generator or motor structure	310	0.000	3.615
Communications, radio wave antennas	343	0.000	3.434
Part of the class 532-570 series—organic compounds	560	250.279	3.434
Electricity, conductors and insulators	174	0.000	3.332
Electric power conversion systems	363	0.000	3.235
Semiconductor device manufacturing process	437	0.000	3.206
Part of the class 532-570 series—organic compounds	568	0.000	2.899
Electricity, circuit makers and breakers	200	0.000	2.673
Electrical audio signal processing and systems	381	0.000	2.558
Brushing, scrubbing and general cleaning	15	0.000	2.460
Electricity, electrical systems and devices	361	0.000	2.403
Plastic and nonmetallic article shaping or treating: Process	264	0.000	2.227
Catalyst, solid sorbent, or support therefor, prod. or proc.	502	0.000	2.167
Dynamic information storage or retrieval	369	0.000	2.016
Recorders	346	0.000	1.962
Adhesive bonding and misc. chemical manufacture	156	0.000	1.685
Telephonic communications	379	0.000	1.666
Supports	248	0.000	1.597
Chemistry, inorganic	423	0.000	1.569
Communication, electrical	340	0.000	1.526
Part of the class 520 series—synth. resins or natural rubber	528	0.000	1.526
Part of the class 520 series—synth. resins or natural rubber	524	0.000	1.389
Coating processes	427	0.000	1.294
Special receptacle or package	206	0.000	1.205
Food or edible material: Processes, compositions and products	426	0.000	1.143
Part of the class 520 series—synth. resins or natural rubber	525	0.000	1.100
Chemistry, electrical and wave energy	204	0.000	1.077
Compositions	252	0.000	0.842
Measuring and testing	73	0.000	0.703
Optics, systems and elements	350	0.000	0.561
Drug, bio-affecting and body treating compositions	514	0.000	0.363

NOTES: The activity index is the percentage of the patents in a class that are granted to South Korean inventors, divided by the percentage of all patents that have South Korean inventors in that year. Listing is limited to U.S. Patent Office classes that received at least 200 patents from all countries in 1989.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1989," report prepared for the National Science Foundation (Washington, DC: October 1990).

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Appendix table 6-30.
Nation shares of patents granted in the United States, by country of residence of inventor, product field, and year of grant: 1980 and 1989

Product field and SIC code	All countries	United States	Japan	West Germany	France	United Kingdom	Canada	Switzerland	USSR	Taiwan	South Korea	Other countries
1980												
		Percent										
ALL PRODUCT FIELDS	61,807	60.4	11.5	9.3	3.4	3.9	1.7	2.0	0.7	0.1	0.0	6.8
Industrial inorganic chemicals (SIC 281)	1,093	59.6	11.3	8.9	4.0	5.3	1.9	1.1	0.9	0.0	0.0	7.0
Plastics materials and synthetic resins (SIC 282)	965	56.6	15.1	13.4	2.9	2.0	0.8	2.3	1.1	0.0	0.1	5.7
Drugs and medicines (SIC 283)	1,378	49.5	12.3	11.6	5.3	8.0	0.9	4.1	0.5	0.1	0.0	7.8
Engines and turbines (SIC 351)	635	51.3	19.8	10.9	3.8	6.0	1.1	1.1	0.3	0.3	0.0	5.4
Office computing and accounting machines (SIC 357)	1,464	61.1	17.3	6.9	3.4	3.0	0.6	1.7	0.4	0.1	0.0	5.5
Radio and TV receiving equipment (SIC 365)	629	47.1	34.5	5.2	2.4	3.5	0.8	1.3	0.2	0.2	0.0	4.9
Communication equip. & elect. comp. (SIC 366-367)	5,684	63.9	14.8	5.9	3.9	3.5	1.4	1.1	0.5	0.1	0.0	4.9
Motor vehicles and equipment (SIC 371)	1,255	52.7	16.4	13.7	4.6	4.7	1.8	1.4	0.2	0.1	0.0	4.4
Aircraft and parts (SIC 372)	679	50.7	19.3	11.5	5.0	6.5	1.2	0.9	0.1	0.1	0.0	4.7
Professional & scientific instruments (SIC 38-3825)	7,618	58.3	16.7	9.0	2.8	3.2	1.4	2.2	0.7	0.1	0.0	5.6
1989												
ALL PRODUCT FIELDS	94,936	52.5	21.1	8.7	3.3	3.2	2.1	1.4	0.2	0.6	0.2	7.6
Industrial inorganic chemicals (SIC 281)	1,253	55.1	14.0	11.6	4.6	4.6	2.4	1.0	0.4	0.0	0.2	6.5
Plastics materials and synthetic resins (SIC 282)	1,373	50.0	21.6	13.2	3.4	3.4	1.0	1.7	0.1	0.0	0.1	5.6
Drugs and medicines (SIC 283)	2,352	51.7	14.3	9.9	3.8	3.8	1.7	2.3	0.2	0.0	0.0	12.5
Engines and turbines (SIC 351)	827	44.9	27.4	12.0	2.4	2.4	1.0	1.3	0.2	0.7	0.2	8.6
Office computing and accounting machines (SIC 357)	3,791	44.2	40.0	4.8	2.5	2.5	0.9	0.7	0.0	0.2	0.2	4.4
Radio and TV receiving equipment (SIC 365)	1,065	35.0	45.3	5.9	3.2	3.2	0.8	0.2	0.0	0.4	0.9	6.4
Communication equip. & elect. comp. (SIC 366-367)	12,399	48.8	31.1	5.5	3.5	3.5	1.6	0.7	0.1	0.5	0.3	5.3
Motor vehicles and equipment (SIC 371)	2,002	40.9	31.9	12.9	2.9	2.9	1.9	0.7	0.0	0.5	0.1	5.8
Aircraft and parts (SIC 372)	1,015	44.0	27.4	12.4	3.6	3.6	1.0	0.9	0.1	0.7	0.0	7.0
Professional & scientific instruments (SIC 38-3825)	13,279	52.0	26.7	6.8	2.9	2.9	1.3	1.3	0.2	0.4	0.0	6.0

NOTE: Table profiles patent activity in SIC-based product fields. The Patent Office's Concordance computer program assigns patent subclasses to all product fields to which they are pertinent; fractional counts are used to eliminate multiple counts among product field categories.

SOURCE: Patent and Trademark Office, *Patenting Trends in the United States, 1963-1989* (Washington, DC: August 1990).

Science & Engineering Indicators – 1991

Appendix table 6-31.

Patents granted in selected countries by residence of inventor: 1985-89

(page 1 of 2)

			Residence of inventor									
Granting country	Total patents	Patents to nonresidents as percent of total	United States	Japan	West Germany	France	United Kingdom	Italy	Sweden	India	Soviet Union	Other nonresidents
1985												
			Percentage of nonresident patents									
Japan	50,100	15.5	46.4	0.0	19.6	6.4	5.4	1.5	2.3	0.0	1.4	17.0
West Germany	33,377	60.4	29.2	23.9	0.0	12.4	6.7	2.8	2.8	0.0	1.7	20.5
France	37,530	73.8	27.4	15.8	25.9	0.0	5.9	4.1	2.4	0.0	1.3	17.0
United Kingdom	34,480	82.3	28.6	20.8	20.9	8.4	0.0	2.9	2.2	0.0	0.6	15.6
Italy	47,924	79.0	6.1	2.3	8.0	4.2	2.0	0.0	0.4	0.0	0.0	77.0
Canada	18,697	92.8	54.8	11.7	8.8	5.6	5.3	1.5	1.8	0.0	0.4	10.0
Mexico	1,374	93.4	56.3	6.6	7.6	7.0	4.0	2.6	1.5	0.0	0.5	14.0
Brazil	3,934	84.6	37.0	7.3	20.7	9.9	4.0	4.6	2.8	0.0	0.4	13.3
South Korea	2,268	84.6	30.4	42.3	6.2	5.4	3.5	1.8	1.4	0.0	0.0	9.1
Soviet Union	74,745	2.0	13.7	8.4	16.9	8.2	3.1	3.9	2.7	0.0	0.0	42.9
India	1,814	76.2	33.5	6.4	11.2	8.1	10.1	3.4	1.3	0.0	3.0	23.0
1986												
Japan	59,900	14.4	46.1	0.0	20.0	6.7	5.3	2.0	2.2	0.0	1.4	16.3
West Germany	38,995	60.6	30.6	24.1	0.0	11.6	6.8	2.8	2.9	0.0	1.1	20.1
France	35,549	73.7	27.8	17.1	25.4	0.0	6.2	3.8	2.3	0.0	0.7	16.7
United Kingdom	32,929	83.6	28.7	19.9	21.6	8.3	0.0	2.8	2.2	0.0	0.4	16.1
Italy	52,493	23.9	24.9	8.2	28.4	13.8	7.4	0.0	1.5	0.0	0.0	15.8
Canada	17,550	92.2	56.0	12.2	7.9	5.2	5.3	1.8	1.8	0.0	0.2	9.6
Mexico	1,222	96.2	61.3	5.6	7.6	6.6	3.2	2.5	1.3	0.1	0.3	11.5
Brazil	2,935	84.9	38.2	9.6	18.8	7.2	3.5	4.3	2.7	0.0	0.2	15.4
South Korea	1,894	75.8	25.4	58.6	0.0	3.1	2.2	1.7	0.8	0.1	0.0	8.1
Soviet Union	79,367	1.6	14.4	7.3	17.4	9.6	5.0	3.4	3.8	0.0	0.0	39.1
India	1,994	75.2	32.3	7.6	6.3	6.5	14.7	4.5	1.8	0.0	2.8	23.5
1987												
Japan	62,400	13.3	38.8	0.0	19.3	6.5	4.5	2.0	1.8	0.0	1.3	14.6
West Germany	39,897	59.4	27.3	25.4	0.0	11.8	6.7	3.1	2.7	0.0	0.9	19.9
France	30,413	72.0	26.4	18.2	29.1	0.0	6.4	4.2	2.4	0.0	0.7	18.3
United Kingdom	28,659	83.9	26.6	20.9	24.1	10.1	0.0	3.1	2.2	0.0	0.3	17.0
Italy	11,550	99.0	25.1	10.3	34.6	16.9	8.1	0.0	2.2	0.0	0.0	98.6
Canada	14,649	92.6	63.3	14.8	9.9	5.4	5.9	1.8	2.2	0.0	0.2	11.6
Mexico	1,406	94.6	136.7	14.9	18.3	16.6	7.0	7.6	4.8	0.1	0.5	29.4
Brazil	2,184	86.8	55.6	8.7	21.7	11.8	10.4	6.2	3.0	0.0	0.5	16.8
South Korea	2,330	74.4	26.8	44.0	5.5	3.3	3.0	1.7	0.8	0.0	0.0	7.2
Soviet Union	85,018	1.6	13.0	9.3	22.6	6.5	4.3	3.3	3.2	0.2	0.0	39.4
India	2,027	73.1	62.9	10.6	19.8	15.9	20.2	3.8	3.7	0.0	5.0	33.2
1988												
Japan	55,300	13.4	43.7	0.0	21.8	7.3	5.0	2.2	2.0	0.0	1.5	16.5
West Germany	38,890	59.6	27.9	26.0	0.0	12.0	6.8	3.2	2.8	0.0	0.9	20.3
France	31,956	72.4	25.0	17.2	27.5	0.0	6.0	4.0	2.2	0.0	0.7	17.3
United Kingdom	29,564	85.0	25.5	20.0	23.0	9.7	0.0	3.0	2.1	0.0	0.3	16.3
Italy	25,195	88.9	12.8	5.3	17.6	8.6	4.2	0.0	1.1	0.0	0.0	50.3
Canada	16,813	93.0	55.0	12.8	8.6	4.7	5.1	1.6	1.9	0.0	0.2	10.1
Mexico	3,411	92.0	58.0	6.3	7.7	7.0	3.0	3.2	2.0	0.0	0.2	12.5
Brazil	3,040	84.0	41.2	6.5	16.1	8.8	7.7	4.6	2.2	0.0	0.4	12.5
South Korea	2,174	73.6	29.0	47.7	6.0	3.6	3.3	1.8	0.9	0.0	0.0	7.8
Soviet Union	83,983	1.6	12.7	9.2	22.2	6.4	4.3	3.2	3.2	0.2	0.0	38.6
India	3,454	75.1	35.9	6.1	11.3	9.1	11.5	2.2	2.1	0.0	2.9	18.9

(continued)

Appendix table 6-31.

Patents granted in selected countries by residence of inventor: 1985-89

(page 2 of 2)

			Residence of inventor									
Granting country	Total patents	Patents to non-residents as percent of total	United States	Japan	West Germany	France	United Kingdom	Italy	Sweden	India	Soviet Union	Other nonresidents
						1989						
			Percentage of nonresident patents									
Japan	63,301	13.5	44.4	0.0	21.2	7.6	5.0	2.2	2.3	0.0	1.3	16.0
West Germany	42,233	60.0	28.2	27.2	0.0	10.9	6.5	3.5	2.8	0.0	0.9	20.0
France	32,879	74.8	24.9	17.5	27.8	0.0	6.0	4.4	2.2	0.0	0.5	16.7
United Kingdom	30,897	86.3	25.7	20.4	23.2	9.1	0.0	3.2	2.1	0.0	0.3	16.0
Italy	15,832	98.7	22.8	9.1	29.4	12.9	6.7	0.0	2.4	0.0	0.0	16.7
Canada	16,299	93.4	52.9	13.7	8.6	6.1	5.7	1.8	1.7	0.0	0.2	9.4
Mexico	2,268	91.0	63.1	4.5	7.8	6.0	2.8	3.5	1.4	0.0	0.7	10.3
Brazil	3,510	86.5	41.2	5.2	16.2	9.1	10.0	4.3	2.2	0.0	0.6	11.1
South Korea	3,972	70.3	30.7	50.6	5.1	3.0	3.0	0.9	0.8	0.0	0.0	6.0
Soviet Union	84,577	1.5	13.6	8.3	19.5	7.0	4.1	4.8	1.9	0.0	0.0	40.8
India	1,986	78.0	35.4	6.8	14.0	7.2	7.3	2.8	1.7	0.0	5.0	19.6

SOURCE: World Intellectual Property Organization, "Industrial Property Statistics" (Geneva, Switzerland).

See figure 6-20.

Science & Engineering Indicators – 1991

Appendix table 6-32.

Citations per patent for selected countries, by year patent was granted in the United States: 1980, 1985, and 1987

Industry	United States	West Germany	Japan	United Kingdom	France	Non-U.S.	World
	1980						
ALL INDUSTRIES	3.58	2.86	3.79	3.12	2.82	3.09	3.39
Industrial inorganic chemicals	3.98	3.32	3.75	4.13	2.94	3.46	3.77
Plastic materials and synthetic resins	3.94	3.24	4.61	3.36	2.36	3.78	3.87
Drugs and medicines	3.46	2.37	2.45	2.75	1.94	2.32	2.88
Engines and turbines	3.23	3.22	4.35	2.41	2.70	3.37	3.30
Office computing and accounting machines	6.80	4.89	6.37	6.09	5.61	5.63	6.34
General industry machines and equipment	3.11	2.46	3.77	2.30	2.45	2.71	2.94
Electrical equipment except communication equipment	3.77	3.10	3.71	3.43	2.80	3.15	3.52
Communication equipment and electrical components	4.95	3.24	4.43	4.37	3.65	4.01	4.60
Radio and TV equipment except communication types	4.60	3.80	3.93	4.64	4.42	4.05	4.30
Electrical components & access & communication equip	4.98	3.18	4.56	4.34	3.60	4.01	4.63
Transportation equipment	2.82	3.07	4.24	2.28	2.50	3.13	2.95
Motor vehicles and motor vehicle equipment	3.14	3.17	4.33	2.37	2.72	3.30	3.22
Guided missiles and space vehicles and parts	2.00	2.07	0.00	0.85	1.80	2.00	2.00
Ordnance, except missiles	2.01	1.82	2.17	1.14	2.70	2.04	2.01
Aircraft and parts	3.39	3.78	4.41	2.45	2.87	3.56	3.48
Professional and scientific instruments	4.25	3.52	3.93	4.68	3.71	3.69	4.02
	1985						
ALL INDUSTRIES	2.07	1.69	2.66	1.79	1.61	2.04	2.06
Industrial inorganic chemicals	2.12	1.34	2.36	1.83	1.44	1.74	1.96
Plastic materials and synthetic resins	2.03	1.68	2.06	1.34	1.67	1.88	1.97
Drugs and medicines	1.77	1.60	1.39	1.53	1.01	1.32	1.54
Engines and turbines	1.37	1.58	2.84	1.27	1.61	2.17	1.85
Office computing and accounting machines	3.50	2.62	3.68	2.97	3.44	3.39	3.44
General industry machines and equipment	1.74	1.49	2.14	1.58	1.58	1.72	1.73
Electrical equipment except communication equipment	2.21	1.96	2.55	2.00	1.65	2.12	2.17
Communication equipment and electrical components	3.08	2.36	3.47	2.46	2.39	2.99	3.04
Radio and TV equipment except communication types	3.03	3.24	3.20	2.73	2.46	2.99	3.01
Electrical components & access & communication equip	3.08	2.27	3.51	2.44	2.38	2.99	3.04
Transportation equipment	1.60	1.95	3.53	1.40	2.02	2.50	2.08
Motor vehicles and motor vehicle equipment	1.80	1.97	3.57	1.53	2.21	2.70	2.32
Guided missiles and space vehicles and parts	1.23	1.20	0.00	0.88	0.84	0.86	1.10
Ordnance, except missiles	1.37	1.39	2.00	1.24	1.52	1.34	1.36
Aircraft and parts	1.51	2.14	3.36	1.47	1.94	2.62	2.14
Professional and scientific instruments	2.46	1.91	2.87	2.10	1.64	2.35	2.41
	1987						
ALL INDUSTRIES	1.01	0.75	1.30	0.82	0.77	0.97	0.99
Industrial inorganic chemicals	0.94	0.54	0.91	1.11	0.60	0.71	0.84
Plastic materials and synthetic resins	0.97	0.53	0.89	0.84	0.68	0.75	0.87
Drugs and medicines	0.88	0.75	0.69	0.71	0.50	0.67	0.78
Engines and turbines	0.73	0.86	1.38	0.61	0.62	1.03	0.91
Office computing and accounting machines	1.63	0.98	1.53	1.50	1.24	1.43	1.51
General industry machines and equipment	0.78	0.68	1.07	0.71	0.90	0.82	0.80
Electrical equipment except communication equipment	1.09	0.76	1.17	0.82	0.88	0.95	1.02
Communication equipment and electrical components	1.45	0.94	1.71	1.14	0.95	1.42	1.43
Radio and TV equipment except communication types	1.60	1.09	1.91	1.28	1.52	1.68	1.65
Electrical components & access & communication equip	1.44	0.93	1.68	1.13	0.92	1.38	1.41
Transportation equipment	0.77	1.01	1.71	0.80	0.82	1.21	1.02
Motor vehicles and motor vehicle equipment	0.85	1.03	1.70	0.82	0.97	1.32	1.15
Guided missiles and space vehicles and parts	0.49	0.45	1.00	1.42	0.38	0.70	0.57
Ordnance, except missiles	0.61	0.46	1.04	0.70	0.80	0.53	0.57
Aircraft and parts	0.78	1.04	1.64	0.77	0.86	1.24	1.05
Professional and scientific instruments	1.20	0.94	1.48	1.01	0.97	1.19	1.20

NOTE: Citation rates generally increase as a patent ages. Consequently, citation rates for patents granted in 1987 are noticeably lower than those granted in 1980.

SOURCE: Computer Horizons, Inc., special report to Science Resources Studies Division, National Science Foundation, 1990.

Appendix table 6-33.
Output per worker-hour in manufacturing: 1960-89

	France	West Germany	Japan	United Kingdom	Italy	Sweden	United States
1960	36.7	45.8	20.2	57.5	34.1	47.0	59.8
1961	39.0	47.0	22.4	56.8	36.4	48.8	61.6
1962	41.3	48.9	22.8	57.5	39.1	52.0	64.8
1963	43.4	50.1	24.5	60.5	40.3	54.4	69.4
1964	46.3	54.3	27.5	65.0	40.7	58.4	73.3
1965	49.0	57.4	28.2	66.0	43.9	62.1	76.1
1966	53.1	59.1	31.2	66.9	48.2	64.6	77.2
1967	55.8	61.3	35.8	69.6	51.3	68.9	76.0
1968	59.8	67.1	40.2	75.2	55.3	73.6	78.6
1969	64.9	71.7	45.8	77.0	57.0	77.8	79.3
1970	67.7	73.4	50.9	77.4	59.5	79.4	77.9
1971	70.9	74.4	53.0	79.2	58.9	82.5	82.5
1972	73.2	78.3	57.9	82.9	63.5	84.3	87.3
1973	77.0	82.6	63.4	90.1	69.5	88.9	91.9
1974	77.5	83.9	63.0	88.6	71.8	91.5	87.8
1975	78.0	85.3	62.3	86.4	68.1	91.0	88.9
1976	83.5	93.8	69.1	90.9	77.3	91.2	94.0
1977	87.6	95.2	73.5	92.4	78.6	89.1	97.4
1978	90.9	97.0	79.9	93.3	83.6	89.1	99.0
1979	95.2	100.2	85.8	93.9	90.7	84.6	98.4
1980	95.9	99.2	91.7	90.4	95.3	95.1	97.3
1981	97.6	99.4	94.5	93.6	97.9	95.5	99.4
1982	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
1983	102.0	104.7	106.0	108.8	105.3	105.5	108.3
1984	104.0	108.1	115.0	115.7	115.8	112.6	115.8
1985	107.7	110.2	120.9	119.7	121.0	112.1	121.1
1986	109.9	108.4	121.9	124.0	125.2	112.4	125.6
1987	113.5	105.9	132.0	132.5	130.9	113.0	130.7
1988	119.6	110.4	139.5	140.2	139.3	115.2	135.4
1989	124.5	114.2	146.1	145.9	143.0	116.0	137.8

NOTE: Index: 1982 = 100.

SOURCE: Bureau of Labor Statistics, unpublished tabulations.

See figure 6-21.

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Appendix table 6-34.
Manufacturers' use and planned use of certain advanced technologies in the United States, Canada, and Australia

Technology	United States		Canada		Australia	
	In use	Plan to use within 5 years	In use	Plan to use within 5 years	In use	Plan to use within 5 years
	Percentage of establishments					
At least one of the 17 advanced technologies	68.4	59.7	43.0	NA	33.0	NA
Design and engineering						
Computer-aided design (CAD) or computer-aided engineering	39.0	19.6	17.0	12.0	10.0	11.0
CAD output used to control manufacturing machines	16.9	21.1	7.0	10.0	4.0	7.0
Digital representation of CAD output used in procurement	9.9	17.5	4.0	8.0	4.0	6.0
Fabrication/machining and assembly						
Flexible manufacturing cells or systems	10.7	11.5	7.0	3.0	1.0	3.0
Numerically controlled or computer numerically controlled machines	41.4	7.9	14.0	4.0	13.0	5.0
Materials working lasers	4.3	9.1	2.0	4.0	1.0	3.0
Pick and place robots	7.7	12.2	3.0	4.0	2.0	4.0
Other robots	5.7	11.2	3.0	5.0	3.0	2.0
Automated material handling						
Automatic storage and retrieval systems	3.2	5.8	4.0	4.0	2.0	3.0
Automatic guided vehicle systems	1.5	3.8	2.0	3.0	1.0	2.0
Automated sensor-based inspection or testing						
Performed on incoming or in-process materials	10.0	11.9	9.0	7.0	3.0	3.0
Performed on final product	12.5	12.4	8.0	6.0	4.0	3.0
Communication and control						
Local area network (LAN) for technical data	18.9	17.2	11.0	12.0	3.0	5.0
LAN for factory use	16.2	19.1	9.0	12.0	5.0	7.0
Intercompany computer network linking plant to subcontractors, subcontractors, suppliers, or customers	14.8	20.3	10.0	11.0	3.0	5.0
Programmable controllers	32.1	10.7	18.0	6.0	14.0	4.0
Computers used for control on factory floor	27.3	22.0	12.0	13.0	7.0	8.0

NOTES: "Nonuse" is defined as "do not currently use or plan to use in the next 5 years." The U.S. survey included establishments with 20 or more employees selected to represent a universe of almost 40,000 manufacturing establishments classified in Standard Industrial Classification codes 34-38; the Canadian survey covered the use of 22 advanced technologies (the first 17 of which are identical to those included in the U.S. survey) by all manufacturing plants in Canada with 20 or more employees; the Australian survey questioned manufacturers' use of 19 advanced technologies (17 of which are comparable).

SOURCE: Bureau of the Census, *Manufacturing Technology 1988*, SMT(88)-1 (Washington, DC: GPO, 1989); Organisation for Economic Cooperation and Development (OECD), "Survey of Manufacturing Technology in Canada - March 1989," Room Document 6, dist. Nov. 8, 1989; and OECD, "Survey of Manufacturing Technology in Australia," Room Document 15, dist. Nov. 27,1989.

See figure 6-22.

Science & Engineering Indicators – 1991

Appendix table 6-35.

Reasons for manufacturers' nonuse of certain advanced technologies in the United States and Canada

Technology	United States		Canada	
	Not applicable	Not cost effective	Not applicable	Not cost effective
	Percentage of establishments			
Design and engineering				
Computer-aided design (CAD) or computer-aided engineering	21.6	7.7	59.0	8.0
CAD output used to control manufacturing machines	34.0	13.6	70.0	9.0
Digital representation of CAD output used in procurement	40.9	14.1	73.0	9.0
Fabrication/machining and assembly				
Flexible manufacturing cells or systems	46.0	15.0	73.0	10.0
Numerically controlled or computer numerically controlled machines	29.8	8.7	68.0	9.0
Materials working lasers	53.6	16.7	79.0	10.0
Pick and place robots	44.4	20.6	75.0	12.0
Other robots	45.4	21.0	74.0	11.0
Automated material handling				
Automatic storage and retrieval systems	46.0	30.0	72.0	15.0
Automatic guided vehicle systems	51.2	28.2	74.0	15.0
Automated sensor-based inspection or testing				
Performed on incoming or in-process materials	41.9	21.0	67.0	10.0
Performed on final product	40.9	19.4	68.0	10.0
Communication and control				
Local area network (LAN) for technical data	36.7	10.6	64.0	6.0
LAN for factory use	36.9	11.3	64.0	8.0
Intercompany computer network linking plant to subcontractors, subcontractors, suppliers, or customers	34.0	13.9	60.0	10.0
Programmable controllers	32.4	9.9	61.0	8.0
Computers used for control on factory floor	26.1	10.9	61.0	9.0

NOTE: "Nonuse" is defined as "do not currently use or plan to use in the next 5 years."

SOURCE: Bureau of the Census, *Manufacturing Technology 1988*, SMT(88)-1 (Washington, DC: GPO, 1989).

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Appendix table 6-36.
Formation of companies in the United States active in certain high-tech fields: 1970-89

Period formed	All high-tech fields	Automation	Bio-technology	Computer hardware	Advanced materials	Photonics & optics	Software	Tele-communi-cations
	Number of companies							
Total	19,097	1,754	722	3,633	947	1,025	6,238	1,620
1970-74	3,174	366	81	525	208	221	758	281
1975-79	4,984	517	138	969	213	292	1,871	411
1980-84	7,217	615	295	1,457	309	334	2,666	616
1985-89	3,722	256	208	682	217	178	943	312
	Percentage of all high-tech companies formed during each period							
1970-74	100.0	11.5	2.6	16.5	6.6	7.0	23.9	8.9
1975-79	100.0	10.4	2.8	19.4	4.3	5.9	37.5	8.2
1980-84	100.0	8.5	4.1	20.2	4.3	4.6	36.9	8.5
1985-89	100.0	6.9	5.6	18.3	5.8	4.8	25.3	8.4
	Percentage of all high-tech companies formed during 1970-89, by field							
1970-74	16.6	20.9	11.2	14.5	22.0	21.6	12.2	17.3
1975-79	26.1	29.5	19.1	26.7	22.5	28.5	30.0	25.4
1980-84	37.8	35.1	40.9	40.1	32.6	32.6	42.7	38.0
1985-89	19.5	14.6	28.8	18.8	22.9	17.4	15.1	19.3

NOTE: Beside those fields indicated, other high-tech fields included in the data base are chemicals, defense-related, energy, environmental, manufacturing equipment, medical, pharmaceuticals, subassemblies and components, test and measurement, and transportation.

SOURCE: Derived from the CorpTech data base, Corporate Technology Information Services, Inc., Wellesley Hills, MA (Rev 6.0, 1991).

See figure 6-23.

Science & Engineering Indicators – 1991

Appendix table 6-37.
Companies active in high-tech fields, by state

State	All fields	Automation	Bio-technology	Computer hardware	Software	Advanced materials	Photonics & optics	Tele-communi-cations
				Number of companies				
TOTAL	29,761	3,413	974	4,541	7,095	2,302	1,673	2,424
California	5,453	526	157	1,131	1,414	211	398	633
Massachusetts	2,275	256	92	381	576	150	215	220
New York	2,023	241	54	290	474	159	182	196
Pennsylvania	1,730	220	55	275	417	213	56	84
New Jersey	1,626	157	81	219	296	198	121	143
Texas	1,430	91	31	189	387	107	49	117
Connecticut	1,346	182	25	176	261	111	72	90
Illinois	1,261	206	32	142	281	111	64	78
Ohio	1,188	209	23	125	204	193	47	41
Maryland	1,157	93	107	244	292	51	52	118
Kentucky	910	172	9	49	71	97	11	20
Minnesota	858	109	27	135	166	66	38	46
Michigan	837	188	20	71	185	95	37	26
Florida	722	50	23	109	209	30	51	81
Virginia	695	44	15	156	223	39	28	112
All other states	6,250	669	223	849	1,639	471	252	419
				Percent				
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
California	18.3	15.4	16.1	24.9	19.9	9.2	23.8	26.1
Massachusetts	7.6	7.5	9.4	8.4	8.1	6.5	12.9	9.1
New York	6.8	7.1	5.5	6.4	6.7	6.9	10.9	8.1
Pennsylvania	5.8	6.4	5.6	6.1	5.9	9.3	3.3	3.5
New Jersey	5.5	4.6	8.3	4.8	4.2	8.6	7.2	5.9
Texas	4.8	2.7	3.2	4.2	5.5	4.6	2.9	4.8
Connecticut	4.5	5.3	2.6	3.9	3.7	4.8	4.3	3.7
Illinois	4.2	6.0	3.3	3.1	4.0	4.8	3.8	3.2
Ohio	4.0	6.1	2.4	2.8	2.9	8.4	2.8	1.7
Maryland	3.9	2.7	11.0	5.4	4.1	2.2	3.1	4.9
Kentucky	3.1	5.0	0.9	1.1	1.0	4.2	0.7	0.8
Minnesota	2.9	3.2	2.8	3.0	2.3	2.9	2.3	1.9
Michigan	2.8	5.5	2.1	1.6	2.6	4.1	2.2	1.1
Florida	2.4	1.5	2.4	2.4	2.9	1.3	3.0	3.3
Virginia	2.3	1.3	1.5	3.4	3.1	1.7	1.7	4.6
All other states	21.0	19.6	22.9	18.7	23.1	20.5	15.1	17.3

NOTE: Beside those fields indicated, other high-tech fields included in the data base are chemicals, defense-related, energy, environmental, manufacturing equipment, medical, pharmaceuticals, subassemblies and components, test and measurement, and transportation.

SOURCE: Derived from the CorpTech data base, Corporate Technology Services, Inc., Wellesley Hills, MA (Rev 6.0, 1991).

See figure 6-24.

Science & Engineering Indicators – 1991

Appendix table 6-38.

Ownership of companies active in high-tech fields operating in the United States, by country of ownership: March 1991

Country	All fields	Automation	Bio-technology	Computer hardware	Advanced materials	Photonics & optics	Software	Tele-communi-cations
				Number of companies				
Total	30,919	3,413	974	4,541	2,302	1,673	7,095	2,424
United States	27,412	3,066	868	4,212	1,957	1,471	6,887	2,182
Foreign owned	3,507	347	106	329	345	202	208	242
United Kingdom	813	70	17	56	85	53	73	53
Japan	600	66	15	101	42	51	16	66
West Germany	560	79	20	34	82	36	15	17
France	269	26	6	23	40	12	23	24
Switzerland	242	28	8	17	23	13	16	6
Canada	246	20	4	16	18	9	22	27
The Netherlands	144	5	8	17	23	11	10	12
Sweden	170	21	8	12	10	5	8	6
Taiwan	35	0	0	10	0	2	1	6
South Korea	22	1	1	6	1	0	1	3
				Percent				
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	88.7	89.8	89.1	92.8	85.0	87.9	97.1	90.0
Foreign owned	11.3	10.2	10.9	7.2	15.0	12.1	2.9	10.0
United Kingdom	2.6	2.1	1.7	1.2	3.7	3.2	1.0	2.2
Japan	1.9	1.9	1.5	2.2	1.8	3.0	0.2	2.7
West Germany	1.8	2.3	2.1	0.7	3.6	2.2	0.2	0.7
France	0.9	0.8	0.6	0.5	1.7	0.7	0.3	1.0
Switzerland	0.8	0.8	0.8	0.4	1.0	0.8	0.2	0.2
Canada	0.8	0.6	0.4	0.4	0.8	0.5	0.3	1.1
The Netherlands	0.5	0.1	0.8	0.4	1.0	0.7	0.1	0.5
Sweden	0.5	0.6	0.8	0.3	0.4	0.3	0.1	0.2
Taiwan	0.1	*	*	0.2	*	0.1	*	0.2
South Korea	0.1	*	0.1	0.1	*	*	*	0.1

* = less than 0.05 percent

SOURCE: Derived from the CorpTech data base, Corporate Technology Information Services, Inc., Wellesley Hills, MA (Rev 6.0, March 1991).

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Appendix table 6-39.

Source of capital for newly formed high-tech companies

Technology field	Corporate investment only	Private investment only	Venture capital only	Corporate & private investment	Corporate investment & venture capital	Private investment & venture capital	Corporate, private, & venture capital
				Percentage of companies receiving source of capital			
Automation	2.5	77.5	2.5	2.5	0.6	10.0	4.4
Biotechnology	2.7	63.7	3.5	10.6	0.9	9.7	8.8
Computer hardware	2.4	73.7	6.8	4.6	2.4	6.8	3.2
Computer software	3.0	76.9	5.2	2.6	1.1	7.7	3.4
Advanced materials	1.2	78.8	4.7	1.2	2.4	9.4	2.4
Photonics & optics	3.1	73.5	5.1	5.1	1.0	10.2	2.0
Telecommunications	3.2	59.7	8.1	2.2	1.6	19.9	5.4
Weighted average	2.8	74.1	5.9	4.8	1.7	10.8	4.4

NOTE: Private companies formed during 1980-89.

SOURCE: Derived from the CorpTech data base, Corporate Technology Information Services, Inc., Wellesley Hills, MA (Rev 6.0, 1991).

See figure 6-25.

Science & Engineering Indicators – 1991

Appendix table 7-1.
Interest in selected issues

Issue area	Degree of interest	1979	1981	1983	1985	1988	1990
		Percent					
International and foreign policy	Very	24	35	30	33	33	48
	Moderately	53	47	47	51	51	40
	Not at all	22	18	22	16	16	13
New scientific discoveries	Very	36	37	48	44	43	39
	Moderately	49	45	41	44	46	49
	Not at all	15	17	11	13	12	12
Economic issues and business conditions	Very	35	52	57	48	48	51
	Moderately	48	37	33	41	42	40
	Not at all	17	10	10	11	10	10
Use of new inventions and technologies	Very	33	33	42	39	40	39
	Moderately	51	51	45	49	49	49
	Not at all	15	16	12	12	12	12
Space exploration	Very	NA	25	27	29	34	26
	Moderately	NA	44	45	46	47	48
	Not at all	NA	31	28	25	22	26
New medical discoveries	Very	NA	NA	NA	68	72	68
	Moderately	NA	NA	NA	29	25	29
	Not at all	NA	NA	NA	3	3	3
Military and defense policy	Very	NA	NA	43	47	47	55
	Moderately	NA	NA	42	42	42	35
	Not at all	NA	NA	15	11	11	10
Nuclear power issues	Very	NA	NA	NA	NA	NA	42
	Moderately	NA	NA	NA	NA	NA	46
	Not at all	NA	NA	NA	NA	NA	14
Environmental pollution	Very	NA	NA	NA	NA	NA	64
	Moderately	NA	NA	NA	NA	NA	31
	Not at all	NA	NA	NA	NA	NA	5

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested.

"Now, I'd like to go through this list with you again and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed."

NA = not asked

NOTE: Percentages may not total 100 because of rounding.

SOURCE: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991).

See figures 7-1 and 7-18.

Science & Engineering Indicators – 1991

Appendix table 7-2.
Knowledge about selected issues

Issue area	Degree of knowledge	1979	1981	1983	1985	1988	1990
		Percent					
International and foreign policy	Very well-informed	9	17	14	15	14	22
	Moderately well-informed	54	55	51	53	55	57
	Not at all informed	37	28	35	32	31	22
New scientific discoveries	Very well-informed	10	13	13	13	14	14
	Moderately well-informed	52	49	53	59	55	55
	Not at all informed	37	38	34	27	31	31
Economic issues and business conditions	Very well-informed	14	29	27	23	23	25
	Moderately well-informed	55	51	52	51	55	54
	Not at all informed	31	20	20	26	22	20
Use of new inventions and technologies	Very well-informed	10	11	14	13	13	11
	Moderately well-informed	50	48	55	54	51	53
	Not at all informed	40	40	32	34	36	35
Space exploration	Very well-informed	NA	14	13	16	13	11
	Moderately well-informed	NA	46	53	52	53	51
	Not at all informed	NA	40	34	32	34	38
New medical discoveries	Very well-informed	NA	NA	NA	25	22	24
	Moderately well-informed	NA	NA	NA	57	59	57
	Not at all informed	NA	NA	NA	18	19	20
Military and defense policy	Very well-informed	NA	NA	21	21	17	26
	Moderately well-informed	NA	NA	50	48	51	51
	Not at all informed	NA	NA	29	31	32	23
Nuclear power issues	Very well-informed	NA	NA	NA	NA	NA	12
	Moderately well-informed	NA	NA	NA	NA	NA	50
	Not at all informed	NA	NA	NA	NA	NA	38
Environmental pollution	Very well-informed	NA	NA	NA	NA	NA	32
	Moderately well-informed	NA	NA	NA	NA	NA	55
	Not at all informed	NA	NA	NA	NA	NA	13

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested.

"Now, I'd like to go through this list with you again and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed."

NA = not asked

NOTE: Percentages may not total 100 because of rounding.

SOURCE: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991).

See figures 7-1 and 7-18.

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Appendix table 7-3.
Media use: 1990

	TV news viewership			Newspaper readership				Newsmagazine readership			
	Regularly	Occasionally	Not at all	Every day	A few times a week	Once a week	Less than once a week	Regularly	Occasionally	Never	*N*
	Percent										
Total public	75	22	4	57	24	8	10	23	13	64	2,033
Gender											
Male	76	21	4	63	22	6	9	25	16	60	964
Female	74	23	3	52	26	10	11	21	12	68	1,070
Degree level											
No high school degree	77	19	4	53	20	10	17	10	9	81	495
High school graduate[1]	73	24	3	55	27	8	9	24	14	63	1,179
College graduate	75	20	5	70	19	7	4	38	17	45	359
Science & math education[2]											
Low	73	23	3	54	23	10	13	16	11	74	1,263
Medium	76	20	3	59	29	6	7	32	15	53	523
High	76	19	5	70	22	5	4	40	25	36	248
Age											
18-24	64	34	2	32	43	11	15	20	16	63	322
25-34	67	29	4	44	29	16	11	20	16	64	497
35-44	73	23	4	60	26	5	10	26	15	59	366
45-64	81	15	4	71	16	4	9	28	11	61	533
65 and older	87	10	3	78	10	4	8	19	7	74	315
Residence											
Incorporated city	75	22	3	59	24	8	9	23	15	63	1,640
Unincorporated area	73	22	5	51	24	10	15	23	8	69	392

"Now, I'd like to read you a short list of television shows and ask you to tell me whether you watch each show regularly—that is, most of the time— occasionally, or not at all. A morning television news show? An evening television news show? A late night television news show?

"How often do you read a newspaper: every day, a few times a week, once a week, or less than once a week?

"Are there any magazines that you read regularly, that is, most of the time? Are there any other magazines that you read occasionally?"

NOTE: Percentages may not total 100 because of rounding.

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see chapter 7, "The Science and Mathematics Education Index," p. 172.

SOURCE: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991).

See figures 7-2 and 7-3.

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Appendix table 7-4.
Informal science education: 1990

	Science television viewership			Science magazine readership			Annual science museum visits			
	Regularly	Occasionally	Not at all	Regularly	Occasionally	Not at all	Two or more	One	None	*N*
	Percent									
Total public	22	58	21	11	15	74	42	17	41	2,033
Gender										
Male	24	58	18	13	21	66	43	16	41	964
Female	20	57	23	9	10	81	42	18	40	1,070
Degree level										
No high school degree	20	54	26	6	7	87	20	11	70	495
High school graduate[1]	24	57	19	10	18	72	45	21	34	1,179
College graduate	19	63	18	18	20	62	64	14	22	359
Science & math education[2]										
Low	21	57	22	7	12	81	32	17	51	1,263
Medium	22	60	19	16	19	65	56	18	26	523
High	26	57	17	20	25	56	67	15	19	248
Age										
18-24	15	61	24	9	19	73	56	24	20	322
25-34	20	56	24	11	16	73	53	17	29	497
35-44	22	62	16	11	20	70	50	18	33	366
45-64	25	59	15	13	13	74	32	17	51	533
65 and older	26	49	26	9	9	81	19	10	71	315
Residence										
Incorporated city	22	58	20	11	17	73	45	17	38	1,640
Unincorporated area	21	55	25	10	11	79	32	18	50	392

"I'd like to read you a short list of television shows and ask you to tell me whether you watch each show regularly—that is, most of the time—occasionally, or not at all. Nova? National Geographic specials?

"Are there any magazines that you read regularly, that is, most of the time? Are there any other magazines that you read occasionally?

"Let me ask you about your use of museums, zoos, and similar institutions. I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is the last 12 months. A science or technology museum? A zoo or aquarium? A natural history museum?"

NOTE: Percentages may not total 100 because of rounding.

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see chapter 7, "The Science and Mathematics Education Index," p. 172.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

See figures 7-2 and 7-3.

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Appendix table 7-5.

Understanding of scientific concepts: 1990

	Scientific study	Probability	Controlled study	*N*
	Percent			
Total public	18	70	72	2,033
Gender				
Male	19	69	74	964
Female	17	71	70	1,070
Degree level				
No high school degree	5	55	51	495
High school graduate[1]	16	72	75	1,179
College graduate	43	82	88	359
Science & math education[2]				
Low	9	63	66	1,263
Medium	26	79	79	523
High	44	83	85	248
Age				
18-24	22	79	64	322
25-34	21	77	73	497
35-44	24	76	79	366
45-64	15	67	77	533
65 and older	7	45	62	315
Attentive publics				
New scientific discoveries	25	78	75	168
New technologies	22	81	77	148
Nuclear energy	19	70	72	157
Medical discoveries	15	70	72	323
Space exploration	28	81	82	123
Environmental pollution	22	74	76	412

"In your own words, could you tell me what it means to study something scientifically?

"Now, think about this situation. A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness. Does this mean that if their first three children are healthy, the fourth will have the illness? Does this mean that if their first child has the illness, the next three will not? Does this mean that each of the couple's children will have the same risk of suffering from the illness? Does this mean that if they have only three children, none will have the illness?

"Now, think about this problem. Suppose a drug used to treat high blood pressure is suspected of having no effect. There are three different ways scientists might use to investigate this problem. First, they could talk to those patients who have used the drug to get their opinion. Second, they could use their own knowledge of medicine to decide how good the drug is. Third, they could give the drug to some patients but not to others, then compare the results for each group. Which of these three ways do you think that scientists would be most likely to use?"

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see chapter 7, "The Science and Mathematics Education Index," p. 172.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

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Appendix table 7-6.
Understanding of environmental concepts: 1990

	Acid rain			Ozone hole			
	Understand term	Know cause/ source	Identify with pollution	Understand term	Identify with pollution	Know location	*N*
				Percent			
Total public	6	10	31	25	18	11	2,033
Gender							
Male	9	15	33	32	18	17	964
Female	3	5	29	19	17	5	1,070
Degree level							
No high school degree	*	7	20	8	10	3	495
High school graduate[1]	6	9	33	27	19	10	1,179
College graduate	13	16	38	39	24	22	359
Science & math education[2]							
Low	3	7	27	17	15	6	1,263
Medium	8	13	36	33	21	13	523
High	16	18	41	46	25	29	248
Age							
18-24	4	5	38	31	21	11	322
25-34	5	7	29	29	17	13	497
35-44	8	11	34	30	20	13	366
45-64	2	12	28	22	18	9	533
65 and older	3	11	25	10	11	8	315
Attentive publics							
New scientific discoveries	11	18	34	37	30	24	168
New technologies	11	19	33	41	23	26	148
Nuclear energy	13	20	32	37	20	14	157
Medical discoveries	7	11	33	27	22	10	323
Space exploration	15	21	31	49	23	30	123
Environmental pollution	10	13	36	33	22	17	412

"When you read or hear the term 'acid rain,' do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means? What is the primary cause of acid rain?

"Recently, there have been news reports that scientists have discovered a hole in the ozone layer. Have you personally read or heard about the hole in the ozone layer? In regard to the issue about the hole in the ozone layer, would you say that you have a clear understanding of the issue, a general sense of it, or little understanding of it? Please tell me, in your own words, why is there a hole in the ozone layer? Do you know where the hole is located? Where is it located?"

* = less than 0.5 percent

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see chapter 7, "The Science and Mathematics Education Index," p. 172.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

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Appendix table 7-7.
Public attitudes toward science and technology
(page 1 of 2)

		1957	1979	1983	1985	1988	1990
		Percent					
A. "Science and technology are making our lives healthier, easier, and more comfortable."[1]	Agree	94	81	85	86	85	84
	Disagree	3	16	12	11	13	13
	Don't know/no answer	3	3	3	2	2	3
B. "The quality of science and mathematics education in American schools is inadequate."	Agree	NA	NA	NA	63	67	72
	Disagree	NA	NA	NA	29	25	24
	Don't know/no answer	NA	NA	NA	8	7	4
C. "On balance, computers and factory automation will create more jobs than they will eliminate."	Agree	NA	NA	39	48	40	39
	Disagree	NA	NA	55	44	52	53
	Don't know/no answer	NA	NA	6	8	8	8
D. "If scientific knowledge is explained clearly, most people will be able to understand it."	Agree	NA	NA	NA	65	72	73
	Disagree	NA	NA	NA	33	27	25
	Don't know/no answer	NA	NA	NA	2	1	2
E. "We depend too much on science and not enough on faith."[2]	Agree	50	NA	51	57	51	51
	Disagree	21	NA	46	39	43	44
	Neither	13	NA	NA	NA	NA	NA
	Don't know/no answer	16	NA	4	5	6	5
F. "Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Federal Government."	Agree	NA	NA	NA	79	81	80
	Disagree	NA	NA	NA	16	15	16
	Don't know/no answer	NA	NA	NA	5	4	4
G. "One of the bad effects of science is that it breaks down people's ideas of right and wrong."[3]	Agree	23	37	30	37	33	34
	Disagree	67	56	63	57	61	59
	Don't know/no answer	10	7	7	7	6	7
H. "Scientists should be allowed to do research that causes pain and injury to animals like dogs and chimpanzees if it produces new information about human health problems."[4]	Agree	NA	NA	NA	63	53	50
	Disagree	NA	NA	NA	30	42	44
	Don't know/no answer	NA	NA	NA	7	5	6
I. "It is not important for me to know about science in my daily life."	Agree	NA	NA	NA	NA	14	14
	Disagree	NA	NA	NA	NA	84	86
	Don't know/no answer	NA	NA	NA	NA	1	1
J. "Some numbers are especially lucky for some people."	Agree	NA	NA	NA	43	37	36
	Disagree	NA	NA	NA	53	59	60
	Don't know/no answer	NA	NA	NA	4	5	4
K. "Science makes our way of life change too fast."[5]	Agree	43	44	46	44	40	37
	Disagree	51	53	52	53	59	60
	Don't know/no answer	6	3	2	3	2	3
L. "Most scientists want to work on things that will make life better for the average person."	Agree	90	NA	NA	80	80	80
	Disagree	5	NA	NA	16	17	16
	Don't know/no answer	5	NA	NA	4	3	4
M. "Rocket launchings and other space activities have caused changes in our weather."	Agree	NA	NA	NA	44	NA	39
	Disagree	NA	NA	NA	44	NA	47
	Don't know/no answer	NA	NA	NA	12	NA	14
N. "It is not wise to plan ahead because many things turn out to be a matter of good or bad luck anyway."	Agree	NA	NA	NA	24	NA	19
	Disagree	NA	NA	NA	74	NA	80
	Don't know/no answer	NA	NA	NA	2	NA	1

(continued)

Appendix table 7-7.
Public attitudes toward science and technology
(page 2 of 2)

		1957	1979	1983	1985	1988	1990
		Percent					
O. "New inventions will always be found to counteract any harmful consequences of technological development."	Agree	NA	NA	NA	47	NA	37
	Disagree	NA	NA	NA	45	NA	56
	Don't know/no answer	NA	NA	NA	8	NA	7
P. "Every high school student in the United States should be required to take a science course every year."	Agree	NA	NA	NA	69	NA	73
	Disagree	NA	NA	NA	28	NA	25
	Don't know/no answer	NA	NA	NA	3	NA	2
Q. "Every high school student in the United States should be required to take a math course every year."	Agree	NA	NA	NA	87	NA	87
	Disagree	NA	NA	NA	12	NA	12
	Don't know/no answer	NA	NA	NA	1	NA	*
	N =	1,919	1,635	1,631	2,005	2,041	2,033

NA = not asked; * = less than 0.5 percent

NOTE: Percentages may not total 100 because of rounding.

[1] 1957 and 1983 wording: *"Science is making . . ."*; 1979 wording: *"Scientific discoveries are making . . ."*

[2] 1957 wording: *"It has been said that we depend too much on science and not enough on faith. How do you personally feel about that statement?"* This was an open-ended question, coded by the interviewing organization. Those who responded that we should rely more on faith were coded as agreeing; those who said we should rely more on science were coded as disagreeing; those who thought we should rely on both or who saw no conflict were listed as "neither."

[3] 1979 wording: *"Scientific discoveries tend to break down people's ideas of right and wrong."*

[4] 1985 wording: *"Studies (should be permitted) that cause pain and injury to animals like dogs and chimpanzees, but which produce new information about human disease or health problems."*

[5] 1957, 1983, and 1985 wording: *"One trouble with science is that it . . ."; 1979 wording: "Scientific discoveries make our lives change too fast."*

SOURCES: Survey Research Center, *The Public Impact of Science in the Mass Media: A Report on a Nation-Wide Survey for the National Association of Science Writers* (Ann Arbor, MI: Institute for Social Research, University of Michigan, 1958); and J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991).

See figures 7-5, 7-14, 7-15, 7-16, and 7-17, and figures O-24 and O-25 in Overview.

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Appendix table 7-8.
Public assessments of scientific research

		Beneficial			Harmful			
		Strongly	Only slightly	About equal[1]	Only slightly	Strongly	Don't know/ no answer	*N*
		Percent						
Total public	1979	46	23	13	6	4	8	1,635
	1981	42	28	12	12	5	1	1,536
	1985	44	24	4	13	6	9	2,005
	1988	53	22	5	8	4	8	1,042
	1990	47	23	7	10	3	10	2,033
Male	1979	51	22	10	6	3	7	773
	1981	48	27	10	10	5	1	724
	1985	48	22	4	13	6	7	950
	1988	56	22	5	7	4	6	498
	1990	54	23	5	9	4	5	964
Female	1979	42	24	17	6	4	8	862
	1981	37	28	14	14	5	2	812
	1985	40	25	5	14	6	10	1,054
	1988	51	21	5	9	4	10	544
	1990	40	23	9	11	3	14	1,070
Less than high school graduate	1979	26	23	17	10	6	19	465
	1981	26	23	23	18	9	2	385
	1985	20	21	8	19	13	19	507
	1988	33	24	8	15	6	14	293
	1990	24	23	11	16	4	22	495
High school graduate or some college	1979	50	25	12	5	3	3	932
	1981	43	31	9	12	4	1	886
	1985	47	25	4	13	4	7	1,143
	1988	56	23	4	6	4	7	574
	1990	49	25	6	10	3	7	1,179
College graduate	1979	69	17	8	2	3	1	238
	1981	64	22	7	4	2	*	264
	1985	67	22	2	6	2	1	349
	1988	79	14	1	2	1	3	175
	1990	70	18	3	3	1	5	359
Attentive public for new scientific discoveries	1988	60	26	4	5	3	*	81
	1990	61	19	1	5	3	11	168

"People have frequently noted that scientific research has produced both beneficial and harmful consequences. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?

"Would you say that the balance has been strongly in favor of beneficial results, or only slightly? Would you say that the balance has been strongly in favor of harmful results, or only slightly?"

* = less than 0.5 percent

[1] Offered as a response category for the first time in 1990; in prior years, volunteered by respondent.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991) ; and unpublished tabulations.

See figure 7-6 and text table 7-3.

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Appendix table 7-9.
Public confidence in people running various institutions: 1973-90

Institution	1973	1974	1975	1976	1977	1978	1980	1982	1983	1984	1986	1987	1988	1989	1990
	Percent														
Medicine	54	60	50	54	51	46	52	45	51	50	46	52	51	46	46
Scientific community	37	45	38	43	41	36	41	38	41	44	39	45	39	40	37
U.S. Supreme Court	31	33	31	35	35	28	25	30	28	33	30	36	35	34	35
Military	32	40	35	39	36	29	28	31	29	36	31	34	34	32	33
Education	37	49	31	37	41	28	30	33	29	28	28	35	29	30	27
Major companies	29	31	19	22	27	22	27	23	24	30	24	30	25	24	25
Organized religion	35	44	24	30	40	31	35	32	28	31	25	29	20	22	23
Press	23	26	24	28	25	20	22	18	13	17	18	18	18	17	15
Average	35	41	31	36	37	30	33	31	30	34	30	35	31	31	30
N =	1,504	1,484	1,490	1,499	1,530	1,532	1,468	1,506	1,599	989	1,470	1,466	997	1,035	899

"I am going to name some institutions in this country. As far as the people running these institutions are concerned, would you say you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?"

NOTE: Survey was not conducted in 1979 and 1981, and question was not asked in 1985.

SOURCE: National Opinion Research Center, *General Social Surveys, Cumulative Codebook*, J.A. Davis and T.W. Smith, principal investigators (Chicago: University of Chicago, annual series).

See figure 7-7.

Appendix table 7-10.
Assessments of genetic engineering research: 1985 and 1990

		Benefits exceed risks			Risks exceed benefits			
		Substantially	Only slightly	About equal[1]	Substantially	Only slightly	Don't know/ refused to answer	*N*
				Percent				
Total public	1985	23	26	2	14	25	12	2,005
	1990	20	26	5	18	18	13	2,033
Male	1985	26	27	2	12	22	11	950
	1990	21	30	6	16	16	11	964
Female	1985	19	24	2	14	27	15	1,054
	1990	19	22	4	20	20	14	1,070
Less than high school graduate	1985	19	28	1	12	23	17	507
	1990	16	26	7	16	15	20	495
High school graduate or some college	1985	21	23	2	14	27	13	1,143
	1990	19	26	4	20	21	10	1,179
College graduate	1985	32	29	2	12	18	8	349
	1990	29	25	5	15	14	12	359
Attentive public for new scientific discoveries	1990	35	28	5	12	13	7	168
Attentive public for medical discoveries	1990	31	25	3	16	13	12	323

"Some persons have argued that the creation of new life forms through genetic engineering research constitutes a serious risk, while other persons have argued that this research may yield major benefits for society. In your opinion, are the risks of genetic engineering research greater than the benefits, or are the benefits greater than the risks? Would you say that the benefits have substantially exceeded the risks, or only slightly exceeded the risks? Would you say that the risks have substantially exceeded the benefits, or only slightly exceeded the benefits?"

NOTE: Percentages may not total 100 because of rounding.

[1] Offered as a response category for the first time in 1990; in prior years, volunteered by respondent.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

See figure 7-8.

Appendix table 7-11.

Assessments of nuclear power: 1985, 1988, and 1990

		Benefits exceed risks		About equal[1]	Risks exceed benefits		Don't know/ refused to answer	N
		Substantially	Slightly		Slightly	Substantially		
		Percent						
Total public	1985	28	21	1	13	31	6	2,005
	1988	18	23	3	17	30	9	2,041
	1990	24	22	5	13	28	8	2,033
Male	1985	37	21	1	9	26	6	950
	1988	23	26	2	15	25	9	958
	1990	31	24	5	11	26	3	964
Female	1985	18	21	2	16	35	8	1,054
	1988	14	20	3	18	32	12	1,083
	1990	17	21	4	15	30	13	1,070
Less than high school graduate	1985	28	21	1	14	26	11	507
	1988	15	25	4	18	25	14	530
	1990	21	20	6	13	23	18	495
High school graduate or some college	1985	27	21	2	12	32	6	1,143
	1988	18	22	3	17	33	9	1,155
	1990	23	23	4	13	32	6	1,179
College graduate	1985	28	21	1	12	34	4	349
	1988	22	23	2	14	32	8	356
	1990	31	23	4	13	25	4	359
Attentive public for new scientific discoveries	1988	26	34	4	16	25	4	174
	1990	28	31	2	10	24	5	168
Attentive public for nuclear energy	1988	30	17	4	12	30	5	161
	1990	45	13	3	7	31	1	157
Attentive public for new technologies	1988	31	23	6	14	23	4	144
	1990	35	21	4	7	31	2	148
Attentive public for environmental issues	1990	23	20	6	11	34	6	412

"In the current debate over the use of nuclear reactors to generate electricity, there is broad agreement that there are some risks and some benefits associated with nuclear power. In your opinion, are the risks associated with nuclear power greater than the benefits, or are the benefits associated with nuclear power greater than the risks? Would you say that the benefits have substantially exceeded the risks, or only slightly exceeded the risks? Would you say that the risks substantially exceed the benefits, or only slightly exceed the benefits?"

NOTE: Percentages may not total 100 because of rounding.

[1] Offered as a response category for the first time in 1990; in prior years, volunteered by respondent.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

See figure 7-8.

Appendix table 7-12.
Assessments of the space program: 1985, 1988, and 1990

		Benefits exceed costs			Costs exceed benefits			
		Substantially	Slightly	About equal[1]	Slightly	Substantially	Don't know/ refused to answer	*N*
		Percent						
Total public	1985	27	26	2	14	24	7	2,005
	1988	22	24	3	18	26	9	2,041
	1990	18	24	5	16	31	6	2,033
Male	1985	34	29	2	12	18	5	950
	1988	28	26	4	13	22	7	958
	1990	23	25	5	15	27	5	964
Female	1985	21	23	3	16	30	7	1,054
	1988	16	22	3	22	29	8	1,083
	1990	14	22	4	16	35	9	1,070
Less than high school graduate	1985	22	22	3	16	26	11	507
	1988	15	25	3	20	29	8	530
	1990	15	20	7	15	32	11	495
High school graduate or some college	1985	26	27	2	14	26	5	1,143
	1988	21	23	3	17	27	9	1,155
	1990	17	25	3	16	33	6	1,179
College graduate	1985	36	27	2	12	17	6	349
	1988	33	23	3	15	16	10	356
	1990	26	26	5	15	24	4	359
Attentive public for new scientific discoveries	1988	35	24	2	11	22	5	174
	1990	26	35	5	14	18	2	168
Attentive public for new technologies	1988	33	28	1	9	23	5	144
	1990	27	31	2	12	26	2	148
Attentive public for space exploration	1988	46	28	2	7	13	2	164
	1990	35	34	3	11	15	2	123

"Many current issues in science and technology may be viewed as a judgment of relative risks and benefits, or costs and benefits. Thinking first about the space program, some persons have argued that the costs of the space program have exceeded its benefits, while other people have argued that the benefits of space exploration have exceeded its costs. In your opinion, have the costs of space exploration exceeded its benefits, or have the benefits of space exploration exceeded its costs? Would you say that the benefits have substantially exceeded the costs, or only slightly exceeded the costs? Would you say that the costs have substantially exceeded the benefits, or only slightly exceeded the benefits?"

NOTE: Percentages may not total 100 because of rounding.

[1] Offered as a response category for the first time in 1990; in prior years, volunteered by respondent.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); and unpublished tabulations.

See figure 7-9.

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Appendix table 7-13.

Assessments of U.S. strength in education, innovation, and science: 1987 and 1989

		Very strong	Strong	Weak	Very weak	Don't know	*N*
				Percent			
Our system of public education	1987	10	38	40	7	5	4,244
	1989	12	36	41	9	2	2,048
Technical and engineering innovation	1987	19	51	21	2	7	4,244
	1989	17	52	24	3	4	2,048
Scientific research	1989	23	56	14	2	5	2,048

"Would you say today that the United States is very strong, strong, weak, or very weak compared to other countries in the following areas?"

SOURCE: Times Mirror Center for the People and the Press, "The People, Press, and Politics," data diskette (Washington, DC: 1989).

See figure 7-12.

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Appendix table 7-14.
Public preferences for spending in the United States: 1973-90

		1973	1974	1975	1976	1977	1978	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990
		Percent															
Space exploration program	Too little	7	8	7	9	10	12	18	12	14	12	11	11	16	18	15	11
	About right	29	27	30	28	34	35	34	41	40	43	44	43	38	42	44	44
	Too much	58	61	58	60	50	47	39	40	40	39	40	41	40	34	35	39
	Don't know/no answer	5	4	4	3	6	6	8	6	6	6	4	5	6	6	7	6
Improving and protecting the environment	Too little	61	59	53	55	47	52	48	50	54	58	56	59	65	65	71	71
	About right	26	26	31	31	34	33	31	32	31	32	31	29	25	26	20	19
	Too much	7	8	10	9	11	10	15	11	8	4	8	5	5	5	4	5
	Don't know/no answer	6	7	6	5	8	5	6	7	7	5	5	7	6	5	5	6
Improving and protecting the Nation's health	Too little	61	64	62	60	56	55	55	56	57	57	58	58	67	66	68	72
	About right	31	28	28	31	32	34	34	32	34	31	33	34	26	28	25	22
	Too much	5	5	5	5	7	7	8	6	5	7	6	4	4	3	3	3
	Don't know/no answer	4	4	4	4	5	4	4	5	4	5	3	4	3	4	4	3
Dealing with drug addiction	Too little	65	60	55	58	54	55	59	57	59	62	62	58	65	68	70	64
	About right	22	28	29	27	29	31	25	27	30	27	28	31	28	24	19	26
	Too much	6	6	8	8	8	9	8	8	5	6	5	6	4	4	6	7
	Don't know/no answer	8	6	8	7	8	5	8	8	6	5	5	5	3	4	4	4
Improving the Nation's education system	Too little	49	50	49	50	48	52	53	56	60	63	60	60	61	63	67	71
	About right	38	37	35	37	39	34	33	32	31	31	31	32	30	29	27	23
	Too much	9	8	11	9	10	11	10	8	6	3	5	4	6	4	3	3
	Don't know/no answer	4	4	4	4	5	4	4	5	3	3	4	3	3	4	4	4
Military, armaments, and defense	Too little	11	17	17	24	24	27	56	29	24	17	14	16	15	16	14	10
	About right	45	45	46	42	45	43	26	36	38	41	42	38	40	40	40	42
	Too much	38	31	31	27	23	22	11	30	32	38	40	40	40	38	39	42
	Don't know/no answer	6	7	7	7	8	8	7	5	6	4	4	5	5	6	6	6
	N =	1,504	1,484	1,490	1,499	1,530	1,532	1,468	1,506	1,599	490	751	730	485	718	768	674

"We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one I'd like you to tell me whether you think we're spending too much money on it, too little money, or about the right amount."

NOTES: Survey was not conducted in 1979 and 1981. Percentages may not total 100 because of rounding.

SOURCE: National Opinion Research Center, *General Social Surveys, Cumulative Codebook*, J.A. Davis and T.W. Smith, principal investigators (Chicago: University of Chicago, annual series).

See figure 7-13 and figure O-25 in Overview.

Science & Engineering Indicators – 1991

Appendix table 7-15.
International comparisons of public attitudes toward science and technology

	A	B	C	D	E	F	G	H	*N*
	Percentage who agree								
Canada	80	52	45	NA	46	22	NA	NA	1,000
Europe[1]	73	27	46	74	59	37	34	46	11,677
Belgium	68	28	35	70	53	41	39	42	1,000
Denmark	68	29	38	72	58	34	16	40	1,013
France	76	19	45	91	58	36	44	58	1,004
Great Britain	76	27	44	83	51	29	24	42	976
Greece	84	36	52	73	76	45	57	57	1,000
Ireland	70	20	45	74	54	35	28	48	1,006
Italy	71	23	55	77	65	37	40	49	1,022
Luxembourg	76	23	46	78	62	27	30	41	303
The Netherlands	75	26	42	78	60	39	23	28	1,025
Portugal	60	26	39	49	51	33	39	43	1,000
Spain	67	19	57	72	70	46	38	57	1,001
West Germany	74	24	38	53	53	36	29	35	1,024
United States	83	39	51	80	37	14	NA	NA	2,033

A *"Science and technology are making our lives healthier, easier, and more comfortable."*
B *"On balance, computers and factory automation will create more jobs than they will eliminate."* Canadian wording: *"On balance, more jobs will be created than lost as a result of computers and factory automation."*
C *"We depend too much on science and not enough on faith."*
D *"Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge should be supported by the government."*
E *"Science makes our way of life change too fast."*
F *"It is not important for me to know about science in my daily life."*
G *"Scientists can be trusted to make the right decisions."*
H *"The benefits of science are greater than any harmful effects."*

NA = not asked

[1] "Europe" includes 300 respondents from Northern Ireland not otherwise broken out here.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); E.F. Einsiedel, Scientific Literacy: A Survey of Adult Canadians (Calgary, Alberta: Graduate Program in Communication Studies, University of Calgary, 1990); and Commission of the European Communities, unpublished tabulations.

See figure 7-16.

Appendix table 7-16.
Japanese public attitudes toward science and technology: 1990

	Strongly agree	Agree	Disagree	Strongly disagree	Not sure/ don't know
			Percent		
1. "Science and technology are making our lives healthier, easier, and more comfortable."	14	40	26	6	13
2. "Science and technology are making our jobs more interesting."	10	32	31	5	22
3. "The widespread use of robots and computers is decreasing the number of jobs."	12	44	28	5	13
4. "Science and technology will solve most of the economic and social problems we face today."	4	20	44	14	17
5. "The study of science and mathematics in school is helpful in developing students' ability to think logically and systematically."	7	41	27	6	18
6. "In comparison to other countries, Japan doesn't have a good environment in which the individual creative scientist can work and develop."	14	44	19	3	20

	Improved	Not changed	Worsened	Don't know
7. "Do you think science and technology have improved, worsened, or not changed the following?"				
Our standard of living	76	15	3	6
Working conditions	48	24	14	14
Morality	8	35	38	20

	Positive	About the same	Negative	Don't know
8. "Science and technology have both positive and negative effects. Which do you think has been greater—the positive effects or the negative effects?"	53	31	7	10

N = 2,239

NOTE: Percentages may not total 100 because of rounding.

SOURCE: Office of the Prime Minister of Japan, Public Relations Office, *Opinion Survey on Science, Technology, and Society*, T. Weich, translator (Washington, DC: Science Resources Studies Division, National Science Foundation, 1991).

See figure 7-17.

Science & Engineering Indicators – 1991

Appendix table 7-17.
Interest in and knowledge about science and technology issues

	Percentage very interested in . . .			Percentage very well-informed about . . .			
	New scientific discoveries	New inventions and technology	New medical discoveries	New scientific discoveries	New inventions and technology	New medical discoveries	*N*
Canada[1]	45	38	59	16	12	29	1,000
Europe[2]	34	32	41	12	12	14	11,677
Belgium	28	28	35	12	12	13	1,000
Denmark	28	28	30	9	11	11	1,013
France	52	48	61	18	17	22	1,004
Great Britain	36	37	43	10	11	11	976
Greece	23	20	27	5	5	6	1,000
Ireland	28	30	32	9	10	9	1,006
Italy	39	34	46	18	16	23	1,022
Luxembourg	42	37	41	11	12	13	303
The Netherlands	45	46	59	13	16	20	1,025
Portugal	21	20	25	5	5	6	1,000
Spain	22	22	20	7	7	6	1,001
West Germany	24	19	32	9	10	10	1,024
United States	39	39	68	14	11	24	2,033

[1] The Canadian questionnaire asked about interest in "stories about medicine and health."

[2] "Europe" includes 300 respondents from Northern Ireland not otherwise broken out here.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); E.F. Einsiedel, *Scientific Literacy: A Survey of Adult Canadians* (Calgary, Alberta: Graduate Program in Communication Studies, University of Calgary, 1990); and Commission of the European Communities, unpublished tabulations.

See figure 7-18.

Appendix table 7-18.

Canadian, European, and U.S. perceptions of astrology

	Very scientific	Sort of scientific	Not at all scientific	Don't know	*N*
	Percent				
Canada	10	35	49	7	1,000
Europe[1]	14	41	32	13	11,677
Belgium	13	38	35	15	1,000
Denmark	13	48	24	15	1,013
France	11	50	31	8	1,004
Great Britain	16	38	40	7	976
Greece	18	35	25	22	1,000
Ireland	18	34	27	21	1,006
Italy	12	34	40	15	1,022
Luxembourg	12	50	34	6	303
The Netherlands	11	46	31	12	1,025
Portugal	19	29	15	27	1,000
Spain	30	34	16	21	1,001
West Germany	8	46	32	14	1,024
United States	6	29	60	5	2,033

NOTE: Percentages may not total 100 because of rounding.

[1] "Europe" includes 300 respondents from Northern Ireland not otherwise broken out here.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); E.F. Einsiedel, *Scientific Literacy: A Survey of Adult Canadians* (Calgary, Alberta: Graduate Program in Communication Studies, University of Calgary, 1990); and Commission of the European Communities, unpublished tabulations.

See figure 7-19.

Science & Engineering Indicators – 1991

Appendix table 7-19.

Canadian and U.S. knowledge of science and technology

	Respondents answering correctly	
	Canada	United States
	Percent	
A. "The center of the earth is very hot."	85	79
B. "The oxygen we breathe comes from plants."	80	85
C. "Electrons are smaller than atoms."	47	41
D. "Hot air rises."	96	95
E. "The continents are moving slowly about on the surface of the earth."[1]	75	77
F. "Human beings, as we know them today, developed from earlier groups of animals."[2]	58	45
G. "The earliest humans lived at the same time as the dinosaurs."	46	47
H. "Which travels faster: light or sound?"	74	75
I. "Lasers work by focusing sound waves."	38	37
J. "Does the earth go around the sun, or does the sun go around the earth?"	78	73
K. "How long does it take for the earth to go around the sun?"[3]	51	48
	N = 2,000	2,033
Number of questions answered correctly		
0	0.3	0.3
1	0.5	0.7
2	1.7	1.9
3	3.8	5.2
4	6.1	7.7
5	10.0	11.3
6	14.2	13.6
7	16.3	15.2
8	14.4	15.3
9	13.7	12.3
10	10.5	9.7
11	8.8	6.7
Mean	7.28	7.00
Alpha	0.67	0.68
Standard deviation	2.31	2.37

[1] Canadian wording. U.S. wording was as follows: *"The continents on which we live have been moving their location for millions of years and will continue to move in the future."*

[2] Canadian wording. U.S. wording was as follows: *"Human beings, as we know them today, developed from earlier species of animals."*

[3] Question K was asked if J was answered correctly.

SOURCES: E.F. Einsiedel, *Scientific Literacy: A Survey of Adult Canadians* (Calgary, Alberta: Graduate Program in Communication Studies, University of Calgary, 1990), unpublished tabulations; J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991).

See figure 7-20.

Science & Engineering Indicators – 1991

Appendix table 7-20.
U.S. and European knowledge of science and technology

	A	B	C	D	E	F	G	H	I	J	*N*
	Percentage answering correctly										
Europe[1]	85	81	41	69	47	24	37	57	83	52	11,677
Belgium	85	66	44	65	36	17	31	51	78	50	1,000
Denmark	91	85	35	65	54	50	40	70	81	53	1,013
France	87	82	46	84	49	21	33	69	84	56	1,004
Great Britain	88	76	38	76	56	40	51	73	75	45	976
Greece	78	73	45	51	24	15	17	31	81	55	1,000
Ireland	84	67	34	58	42	29	29	54	73	50	1,006
Italy	80	89	44	72	35	11	32	54	91	58	1,022
Luxembourg	85	86	48	76	59	12	41	67	86	57	303
The Netherlands	87	86	43	75	56	21	50	69	77	42	1,025
Portugal	68	73	33	40	26	6	18	25	80	42	1,000
Spain	73	71	36	60	35	24	25	44	80	55	1,001
West Germany	95	89	39	59	59	30	43	49	86	51	1,024
United States	79	85	41	77	47	30	37	63	73	48	2,033

	Number of questions answered correctly[2]													
	0	1	2	3	4	5	6	7	8	9	10	Mean	Alpha	SD[3]	*N*
	Percentage of respondents														
Denmark	1.4	2.1	3.3	7.1	9.3	12.9	15.4	15.2	14.3	12.3	6.8	6.23	0.71	2.357	1,013
Great Britain	0.9	2.4	4.4	9.7	9.8	9.6	14.5	15.0	14.3	10.6	8.7	6.17	0.73	2.458	976
Luxembourg	0.3	3.0	4.6	5.3	9.6	12.9	15.5	16.5	17.8	10.6	4.0	6.17	0.70	2.245	303
France	0.4	1.4	3.6	7.0	10.6	14.2	17.4	17.1	13.8	11.3	3.2	6.11	0.65	2.125	1,004
The Netherlands	0.7	2.2	3.4	6.8	12.9	13.5	14.9	16.0	14.9	11.0	3.7	6.05	0.67	2.226	1,025
West Germany	0.1	0.9	3.0	9.5	13.1	16.9	17.0	13.6	11.6	8.3	6.1	5.97	0.64	2.145	1,024
United States	0.6	2.6	5.4	9.2	13.0	14.5	16.0	13.0	10.5	9.0	6.1	5.79	0.69	2.350	2,033
EUROPE	1.5	2.6	5.2	9.3	11.9	14.1	15.3	14.2	12.1	9.1	4.6	5.75	0.71	2.368	11,677
Italy	0.8	2.5	6.4	9.7	12.4	15.1	14.1	15.0	12.2	8.8	3.0	5.66	0.73	2.294	1,022
Belgium	2.7	3.3	6.8	11.5	14.1	14.8	15.7	12.8	9.2	6.6	2.5	5.24	0.69	2.355	1,000
Ireland	3.5	4.6	7.2	10.0	13.8	14.8	14.5	12.2	9.6	6.4	3.4	5.19	0.72	2.474	1,006
Spain	4.8	5.3	8.6	10.7	12.6	14.5	12.7	10.5	9.3	8.3	2.7	5.03	0.76	2.603	1,001
Greece	5.1	5.8	8.6	11.6	13.9	14.4	17.4	11.8	5.7	4.0	1.7	4.71	0.73	2.393	1,000
Portugal	8.0	9.3	13.2	12.2	12.7	14.7	11.0	8.3	7.2	2.9	0.5	4.09	0.77	2.481	1,000

A *"The center of the earth is very hot."*
B *"The oxygen we breathe comes from plants."*
C *"Electrons are smaller than atoms."*
D *European wording: "The continents are moving slowly about on the surface of the earth." U.S. wording: "The continents on which we live have been moving their location for millions of years and will continue to move in the future."*
E *"The earliest humans lived at the same time as the dinosaurs."*
F *"Antibiotics kill viruses as well as bacteria."*
G *"Lasers work by focusing sound waves."*
H *European wording: "All radioactivity is manmade." U.S. wording: "Is all radioactivity manmade, or does some radioactivity occur naturally?"*
I *"Does the earth go around the sun, or does the sun go around the earth?"*
J *(Asked if Question I was answered correctly) "How long does it take for the earth to go around the sun?"*

[1] "Europe" includes [illegible] respondents from Northern Ireland not otherwise broken out here.

[2] Ranked on mean number of questions answered correctly.

[3] SD = standard deviation.

SOURCES: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); unpublished tabulations; and Commission of the European Communities, unpublished tabulations.

See figure 7-21 and figure O-26 in Overview.

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Appendix table 7-21.

U.S. public assessments of U.S. international position in basic scientific achievements: 1990

	Europe				Japan				Soviet Union				
	U.S. is ahead	About the same	U.S. is behind	Don't know	U.S. is ahead	About the same	U.S. is behind	Don't know	U.S. is ahead	About the same	U.S. is behind	Don't know	N
						Percent							
Total public	46	36	14	4	23	25	50	3	61	28	7	3	2,033
Gender													
Male	55	30	13	2	29	25	45	1	71	22	4	2	964
Female	38	41	15	6	18	24	54	4	52	34	10	4	1,070
Degree level													
No high school degree	38	36	15	10	27	24	43	6	46	39	8	7	495
High school graduate[1]	47	36	15	2	20	25	55	1	62	28	8	2	1,179
College graduate	53	35	10	2	31	25	43	2	79	15	4	2	359
Science & math education[2]													
Low	44	36	14	6	23	26	48	3	55	33	9	4	1,263
Medium	50	34	15	2	22	21	56	1	67	25	6	2	523
High	49	38	11	2	28	26	45	2	82	14	4	1	248
Age													
18-24	43	38	17	3	11	22	65	1	54	35	11	1	322
25-34	45	39	12	4	20	25	51	3	60	31	7	2	497
35-44	53	30	15	3	24	24	51	1	68	22	8	2	366
45-64	47	35	14	4	32	23	44	1	63	26	8	3	533
65 and older	42	37	14	6	25	29	39	7	59	28	4	8	315
Attentive publics													
New scientific discoveries	55	29	16	*	34	23	42	*	74	20	6	*	168
New technologies	61	27	12	*	33	23	44	*	78	19	3	*	148
Nuclear policy	56	27	17	*	26	27	46	*	76	22	2	*	157
Medical discoveries	50	33	17	*	26	24	50	*	64	28	8	*	323
Space exploration	60	34	6	*	38	25	38	*	77	20	2	*	123
Environmental pollution	50	34	17	*	27	21	52	*	69	27	4	*	412

"Now, let me ask you to think about the relative position of the United States in the world in regard to science and technology. In terms of basic scientific achievements, would you say that the United States is ahead of Europe [Japan, Soviet Union], behind Europe [Japan, Soviet Union], or at about the same level?"

* = less than 0.5 percent

NOTE: Percentages may not total 100 because of rounding.

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see chapter 7, "The Science and Mathematics Education Index," p. 172.

SOURCE: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); unpublished tabulations.

See text table 7-6.

Appendix table 7-22.

European assessments of international positions in science and technology: 1989

	United States			Japan			
	Europe is more advanced	Europe is less advanced	At the same level	Europe is more advanced	Europe is less advanced	At the same level	*N*
Scientific discoveries							
	Percent						
Europe[1]	13	46	29	27	41	18	11,677
Belgium	14	46	26	20	44	18	1,000
Denmark	7	45	35	15	54	17	1,013
France	19	34	38	28	41	21	1,004
Great Britain	18	40	32	30	41	18	976
Greece	12	61	12	14	57	11	1,000
Ireland	10	53	23	20	47	14	1,006
Italy	8	58	22	22	48	14	1,022
Luxembourg	8	44	27	22	40	15	303
The Netherlands	14	42	33	30	41	18	1,025
Portugal	10	42	18	15	39	15	1,000
Spain	7	66	12	14	60	7	1,001
West Germany	15	38	40	39	22	30	1,024
Technology and industry							
Europe[1]	15	42	29	13	61	14	11,677
Belgium	12	44	26	11	55	17	1,000
Denmark	9	44	32	7	74	8	1,013
France	14	39	34	14	62	14	1,004
Great Britain	21	37	31	12	67	13	976
Greece	12	59	12	10	62	10	1,000
Ireland	14	47	24	11	61	11	1,006
Italy	11	49	24	10	66	10	1,022
Luxembourg	14	38	25	10	55	13	303
The Netherlands	18	34	34	11	64	15	1,025
Portugal	8	42	20	9	47	14	1,000
Spain	5	65	13	8	68	6	1,001
West Germany	23	30	38	20	49	23	1,024
Technological advances applied in everyday life							
Europe[1]	13	47	27	19	48	19	11,677
Belgium	10	49	25	14	46	21	1,000
Denmark	10	43	29	15	52	16	1,013
France	15	40	32	18	49	19	1,004
Great Britain	15	49	25	20	51	17	976
Greece	12	57	12	11	59	10	1,000
Ireland	9	51	23	16	49	16	1,006
Italy	8	58	20	14	58	11	1,022
Luxembourg	14	44	22	15	46	18	303
The Netherlands	14	43	29	23	42	21	1,025
Portugal	7	42	20	9	45	16	1,000
Spain	6	61	13	9	60	10	1,001
West Germany	18	33	39	31	26	32	1,024

"For each of the following fields, could you tell me whether you think Europe is ahead or behind or at the same level as the United States [Japan]?"

NOTE: Nonresponses and "don't know" are omitted.

[1] "Europe" includes 300 respondents from Northern Ireland not otherwise broken out here.

SOURCE: Commision of the European Communities, unpublished tabulations.

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Appendix table 7-23.

U.S. public assessments of U.S. international position in military technology: 1990

	Europe				Japan				Soviet Union				
	U.S. is ahead	About the same	U.S. is behind	Don't know	U.S. is ahead	About the same	U.S. is behind	Don't know	U.S. is ahead	About the same	U.S. is behind	Don't know	*N*
						Percent							
Total public	69	26	3	2	71	18	7	4	46	42	9	3	2,033
Gender													
Male	78	19	2	1	84	11	4	1	54	37	8	1	964
Female	61	31	4	4	59	25	10	6	39	46	11	4	1,070
Degree level													
No high school degree	55	37	4	4	62	22	8	8	41	43	10	7	495
High school graduate[1]	71	24	3	2	71	19	8	2	45	44	10	1	1,179
College graduate	82	15	2	2	84	9	4	3	60	33	5	2	359
Science & math education[2]													
Low	64	30	4	3	65	21	9	5	43	44	9	4	1,263
Medium	75	21	3	2	77	15	6	2	48	41	10	1	523
High	86	12	1	1	87	10	3	1	61	32	6	1	248
Age													
18-24	68	25	5	2	67	20	11	2	28	58	14	1	322
25-34	70	25	3	2	71	18	8	3	45	44	10	1	497
35-44	75	22	3	1	74	18	5	3	49	40	9	1	366
45-64	70	25	3	2	78	14	5	2	56	34	7	3	533
65 and older	61	32	2	5	59	24	7	10	48	37	6	9	315
Attentive publics													
New scientific discoveries	77	23	1	*	80	15	6	*	54	36	10	*	168
New technologies	74	24	1	*	83	10	7	*	59	35	6	*	148
Nuclear policy	85	15	*	*	80	16	4	*	66	28	6	*	157
Medical discoveries	77	22	2	*	73	21	6	*	52	39	10	*	323
Space exploration	79	21	1	*	87	11	3	*	58	35	7	*	123
Environmental pollution	80	19	2	*	79	17	5	*	55	38	7	*	412

"In terms of military technology, would you say that the United States is ahead of Europe [Japan, Soviet Union], behind Europe [Japan, Soviet Union], or at about the same level?"

* = less than 0.5 percent

NOTE: Percentages may not total 100 because of rounding.

[1] Includes respondents with associate degrees.

[2] For an explanation of the education index, see chapter 7, "The Science and Mathematics Education Index," p. 172.

SOURCE: J.D. Miller, *Public Attitudes Toward Science and Technology, 1979-1990, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1991); unpublished tabulations.

See text table 7-6.

Appendix B
Contributors and Reviewers

The following persons contributed to the report by reviewing chapters or sections, providing data, or otherwise assisting in its preparation. Their help is greatly appreciated.

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Appendix C
Abbreviations

AAAS	American Association for the Advancement of Science
APL	Applied Physics Laboratory
CAD/CAE	computer-aided design and engineering
CCSSO	Council of Chief State School Officers
CEHR	Committee on Education and Human Resources
CFCs	chlorofluorocarbons
CPRE	Center for Policy Research in Education
CRADA	cooperative research and development agreement
DCAA	Defense Contract Audit Agency
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
EC	European Community
FFRDC	federally funded research and development center
FTTA	Federal Technology Transfer Act
FY	fiscal year
GNP	gross national product
GSP	gross state product
GSS	General Social Survey
GUF	general university funds
HDTV	high-definition television
HHS	Department of Health and Human Services
IR&D	independent research and development
ISIC	International Standard Industrial Classification
JRV	joint research and development venture
LSAY	Longitudinal Study of American Youth
NAEP	National Assessment of Educational Progress
NAS/NRC	National Academy of Science/National Research Council
NASA	National Aeronautics and Space Administration
NCRA	National Cooperative Research Act of 1984
NCTM	National Council of Teachers of Mathematics
NELS:88	National Education Longitudinal Study of 1988
NIH	National Institutes of Health
NORC	National Opinion Research Center
NS&E	natural science and engineering
NSF	National Science Foundation
OECD	Organisation for Economic Cooperation and Development
OES	Occupational Employment Statistics
OMB	Office of Management and Budget
R&D	research and development
R&E	research and experimentation
RDT&E	research, development, test, and evaluation
S&T	science and technology
SASS	Schools and Staffing Survey
SAT	Scholastic Aptitude Test
SBA	Small Business Administration
SBIR	Small Business Innovation Research
SES	socioeconomic status
SIC	Standard Industrial Classification
SIR	statutory invention registration
SME	science, mathematics, and engineering
SS&C	Scope, Sequence, and Coordination project
USDA	Department of Agriculture

Appendix D
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